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Sex Differences in Cognitive Abilities

DIANE F. HALPERN



Fourth Edition

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Diane F. Halpern

Claremont McKenna College

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This book is dedicated to the wonderful children
in my life: Amanda Halpern, Jason Halpern, and
Belle Halpern-Duncan

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Preface to the Fourth Edition

It is hard to believe, but it has been over 10 years since the publication of the third edition of *Sex Differences in Cognitive Abilities* and 25 years since the first edition. I had no idea when I started studying this controversial topic that it would consume so much of my academic life. Much has changed over the intervening two and a half decades, with the pace of change accelerating since the last edition.

The biological revolution has changed our understanding of the mind and behavior in general, but particularly in the way we think about cognitive sex differences. Modern neuroscience has permeated every area of psychology and the other sciences and social sciences, but even with its rapid developments it is clearly in its own infancy. Perhaps one of the greatest contributions from the biological revolution is that we can now see changes in the brain that result from experience. In a strange twist, modern biological techniques have advanced our understanding of the importance of environmental variables.

One of the most distressing outcomes of modern neuroscience is the way findings are being misused to advance political agendas. Fine (2010) has coined the term “neurosexism” for the misuse of neuroscience to justify sex role stereotypes. In a clever play on words, she calls the irresponsible use of findings from the brain sciences “brain scams.” Supporters of the idea that men and women are essentially different—not just in their respective roles in reproduction but in how they learn and think—cite differences in the female and male brain to support their conclusions (e.g., Baron-Cohen, 2004; Brizendine, 2006; Sax, 2005). What they do not understand is the very long leap from neurons to actual behavior and the way experiences alter the brain.

Another major change since the last edition of *Sex Differences in Cognitive Abilities* was published is the many exaggerated and unreplicated claims regarding cognitive sex differences. They crop up in many places. Perhaps the most distressing development is the misuse of what we know about cognitive sex differences to claim that boys and girls are so different they need different types of education. A group of researchers has formed the American Council for Co-Educational Schooling in response to claims that we need to segregate girls and boys in schools. Interested readers are referred to their website,

www.coedschools.org, for answers to frequently asked questions, research, and other data-based information.

There have been many changes in our understanding of cognitive sex differences since the last edition. I am excited about sharing my understanding of this complex and controversial topic with a new generation of readers. Here are just a few that are explained in more detail in the text: differences among average females and males tend to be much smaller than differences found among females and males with low and high abilities; people's beliefs about group stereotypes affect their performance on high stakes examinations, but with minimal interventions belief-related influences can be reduced or eliminated; cross-cultural research has shown that some sex differences are largest in those countries that are the most gender-equal, using many different measures of gender equality; education and training can reduce or eliminate some cognitive sex differences; many of the cognitive differences are directly related to average differences in the interests of males and females; hormones affect cognitive abilities, but their effects are complex and not fully understood; and sex role stereotyping increases when teachers and others make children's sex salient (e.g., boys line up here, this bulletin board is for girls' work).

My goals in writing this book were for readers to come away with an understanding of where sex differences are found and where they are not found; a recognition of the critical importance of good research as well as some idea of what constitutes good research; an amiable skepticism, which means an open-minded questioning about the nature and strength of evidence behind any claim of sex difference; an appreciation of the complexity of the questions about cognitive sex differences; and the ability to see multiple sides of an issue, while also realizing that some claims are well reasoned and supported by data and others are politicized pseudoscience.

In several places in this book, I bring up the idea that people are naturally biased to prefer information that supports their particular world views. Of course, I recognize that I am not immune to personal biases. After the publication of past editions, I received emails claiming that I was biased in favor of biological and in favor of environmental explanations, which I took to mean that I did a good job of upsetting people at both ends of the political spectrum. I have tried to be as fair in presenting all of the relevant data as I can be. I stayed close to the data, describing relevant studies and explaining the findings. But in order for this book to be meaningful, I also presented my interpretation of the research. If you only read selected portions of this book, you will find support for almost any viewpoint, but if you read it all, you will see that there are strong data for many different views and that the totality of the data is what is needed to see the larger picture.

I sincerely thank the many wonderful reviewers for the fourth edition. The list of reviewers is a virtual who's who in the topic areas covered. Reviewers contributed their expertise, which greatly improved this book. I am grateful for the careful reviews by these outstanding psychologists:

Heather Butler, Claremont Graduate University
Beth Casey, Boston College
Jacquelyn Cranney, University of New South Wales, Australia
Alice Eagly, Northwestern University
Sue Frantz, Highland Community College
Richard Haier, University of California, Irvine
Agneta Herlitz, Karolinska Institutet
Mary Hegarty, University of California, Santa Barbara
Lynn Liben, Pennsylvania State University
Carol Lynn Martin, Arizona State University
David I. Miller, University of California, Berkeley
Melanie Page, Oklahoma State University
Patricia Puccio, College of DuPage
Emily Savage-McGlynn, University of Cambridge
Daniel Voyer, University of New Brunswick

Several anonymous reviewers and the students in Psychology 131, Sex Differences in Cognitive Abilities, fall semester 2010 provided helpful comments.

Reviewers for earlier editions are listed in the earlier prefaces. I carefully considered a wide range of reviews, and although I wish that I could blame any errors you may find on the reviewers, I will have to take responsibility for the contents of this book. Research is advancing at a very fast pace. I can only guess at the changes that I will make in the next edition.

I hope you will enjoy reading this book—that it will make you think in new ways about the complexities in cognitive sex differences and that it will inspire the next generation of researchers and inform parents, teachers, and policy makers about the ways in which males and females are different and similar.

With sincere best wishes,

A handwritten signature in black ink that reads "Diane F. Halpern". The signature is written in a cursive, flowing style. The first name "Diane" is written with a large, looped 'D'. The middle initial "F." is smaller and follows the first name. The last name "Halpern" is written with a large, looped 'H' and a trailing flourish.

Preface to the Third Edition

What is the meaning of differences and why are we so afraid of them? These deceptively simple questions are at the heart of this book. Of course, females and males differ in some ways and are similar in others, but where are the differences and the similarities, and how can we make sense out of them? Perhaps there are even more fundamental questions that need to be asked first: Why is it important to know about differences? Are answers even possible given the many ways that belief systems bias the conclusions that we make and the decisions about what we want to know? All of these questions have a long and turbulent history entangled with beliefs about the appropriate roles of men and women and the political and economic ramifications of the way we answer them. The questions and answers are philosophical, empirical, political, historical, and interesting to large numbers of people both inside academia and in the real world that exists beyond the ivy curtain. Those opposed to research on sex differences fear that it will legitimize false stereotypes, obscure similarities, and provide fuel for those determined to convince the world of the inferiority of females or be used in ways that discriminate against males. As I write this preface, the new, repressive government in Afghanistan has forbidden all girls and women from attending school or working outside the home. I hope that this stunning act of discrimination will be history by the time you are reading this book. But, it does underscore an important reality, the potential for the misuse of information on cognitive sex differences is cause for concern; no wonder so many people are afraid of any research that examines group differences.

In writing about such a sensitive and politically explosive topic, I have tried to present the most recent findings along with some age-old questions about “maleness” and “femaleness” in as fair and unbiased way as possible. I wanted to go beyond the pop culture version of sex differences that is presented on talk shows and in the usual array of books found in many book stores to provide a reasoned and empirical view of one of psychology’s most fundamental topics. Of course, by definition, none of us can see our own blind spots, so I am certain that many readers will see biases, especially if the information provided or the way it is presented does not agree with their own favored point of view. Following the publication of previous editions of this book, I received mail

from many readers—some praising my fair-mindedness and the clear way in which I presented information (funny, but I remember these the best), but others taking exception to the way a particular area of research or theory was interpreted. I was pleased to find that the criticisms came from all ends of the political spectra, which I interpreted to mean that I had done a fairly good job of angering all sorts of people. In other words, I had succeeded at interpreting the huge and diverse literature. I hope that this edition comes even closer to achieving that goal.

The years since the publication of the second edition of *Sex Differences in Cognitive Abilities* have seen an explosion of new theories and research into the many questions about sex differences in cognition. New techniques for peering into the human brain have changed the nature of the research questions that we can ask and the kinds of answers we can expect. There have been surprising new findings about the influence of sex hormones throughout the life span for both women and men. Readers are warned that the burgeoning area of cognitive neuroscience is still in its own perinatal period, which means that inferences about the brain bases of cognition are extremely fragile and likely to change as the field develops. There has also been a rapid increase in the number of studies that examine unconscious and automatic processes that influence how people think when they become aware of category variables like one's sex, race, or age. The most important advance since the publication of the second edition of this book is the renewed emphasis on the continuity of environmental and biological variables, a perspective that blurs the distinction between these two types of influences. The psychobiosocial model that I advocate discards the nature–nurture dichotomy and replaces it with a continuous feedback loop in which nature and nurture are inseparable. I hope that this reconceptualization of the variables that influence who we are and how we develop will move us away from the nature–nurture tug-of-war to a more holistic and reciprocal view of human cognitive development.

ACKNOWLEDGMENTS

My sincere thanks goes to those unsung heroes who have read and commented on some or all portions of this book as it progressed through numerous drafts. I am enormously grateful for the insights of Dr. Marcia Collear at Middlebury College, Dr. Ann Gallagher at the Educational Testing Service, and Dr. George Spillach at Washington College. I also thank numerous students who have helped with this edition, especially (soon-to-be-Ph.D.) Mary LaMay at Loma Linda University. Each of these wonderful scholars gave generously of their time and expertise and each of these special people provided encouraging feedback and helpful ideas throughout the writing process.

The contributions of many students who have influenced my thinking and writing are gratefully acknowledged, both those who have asked the “really

tough questions” in my own classes and those who used earlier editions of this book in classes taught by other instructors. I am grateful to all of you who have written and e-mailed from many different places in North America and from numerous countries around the world. Your thoughtful comments, kind words, and unique international perspectives are sincerely appreciated.

Preface to the Second Edition

It seems that everyone has strong opinions about the ways in which females and males do and don't differ. Television talk show hosts and guests regularly "debate" (read, that try to out-shout each other), research findings dot the front pages of newspapers, and the rest of us talk, listen, and argue about the many questions about sex differences and similarities.

Yet, despite all the heated rhetoric, few people outside of academia are aware of the way in which psychologists, biologists, sociologists, and researchers from almost every other discipline have studied the questions about sex differences and similarities and the kinds of answers they have provided. In this book, I synthesize and summarize the enormous research literature that pertains to the ways males and females differ in their cognitive abilities. The intended audience for this book is anyone who wants to read a thoughtful analysis of the complex issues involved in asking and answering multifarious questions. A basic-level background in psychology, biology, and research methods will help readers with some of the more technical points, but readers without such a background can follow the main points. Upper division undergraduates and beginning graduate students should benefit the most from reading this book as they have already addressed some of the issues in their other courses.

I hope that every reader will take away something of value from this book—a new idea, a different way of conceptualizing the issues, a more open mind, an appreciation for the immense complexity of the issues involved, a more thoughtful approach to complicated problems, a framework for interpreting the quality of evidence, an understanding of the way societal values influence the way questions are posed and the type of answers we get, and the knowledge that there is a reciprocal relationship among psychological, biological, and societal influences that makes simple answers to complicated questions simply wrong. This is a long list of desired outcomes, but if most readers gain in at least one of these areas, then, I have successfully accomplished the goals that I set for myself when I began writing.

ACKNOWLEDGMENTS

This is my favorite part, the opportunity to thank the many wonderful colleagues who helped me with this book. I am grateful to Dr. Claire Etaugh at Bradley University and Dr. Nora Newcombe at Temple University for reading an earlier draft of the entire book. Their insightful comments have greatly improved the text. Dr. Neil Campbell from the University of California, Riverside, Dr. Michelle Paludi from Hunter College, Dr. Anne Petersen from Pennsylvania State University, and Dr. JoAnna Worthley from California State University, San Bernardino, all read chapters and generously shared their expertise with me. Of course, I would like to be able to attribute any errors that exist in the text to them, but, unfortunately, I will have to assume this responsibility.

Many colleagues have written to me to share their research and to comment on the myriad of issues. I thank them and the many other researchers whose work I have cited. I also thank my wonderful family, my husband Sheldon and my children Joan and Evan, for “being there” and for acting as sounding boards as I read my way through a mountain of literature and asked them to consider the many questions pertaining to sex differences in cognitive abilities.

Preface to the First Edition

It seemed like a simple task when I started writing this book. All I had to do was provide a comprehensive synthesis of the theories and research concerning the causes, correlates, and consequences of cognitive sex differences and make some meaningful conclusions that were supported in the literature. My interest in the area grew naturally out of several years of teaching both cognitive psychology and psychology of women to college classes. The idea that women and men might actually think differently, that is have different preferred modes of thinking or different thinking abilities, came up in both classes. At the time, it seemed clear to me that any between-sex differences in thinking abilities were due to socialization practices, artifacts and mistakes in the research, and bias and prejudice. After reviewing a pile of journal articles that stood several feet high and numerous books and book chapters that dwarfed the stack of journal articles, I changed my mind. The task I had undertaken certainly wasn't simple and the conclusions that I had expected to make had to be revised.

The literature on sex differences in cognitive abilities is filled with inconsistent findings, contradictory theories, and emotional claims that are unsupported by the research. Yet, despite all of the noise in the data, clear and consistent messages could be heard. There are real, and in some cases sizable, sex differences with respect to some cognitive abilities. Socialization practices are undoubtedly important, but there is also good evidence that biological sex differences play a role in establishing and maintaining cognitive sex differences, a conclusion that I wasn't prepared to make when I began reviewing the relevant literature.

The conclusions that I reached about cognitive sex differences are at odds with those of other authors (e.g., Caplan, MacPherson, & Tobin, 1985; Fairweather, 1976). There are probably several reasons why the conclusions in this review are different from the earlier ones. I believe that the data collected within the last few years provide a convincing case for the importance of biological variables, and that earlier reviews were, of course, unable to consider these findings. Other reviewers were sometimes quick to dismiss inconsistent theories and experimental results as symptomatic of a chaotic field of investigation. If they had reviewed the inconsistencies, they would have found that

many of them are resolvable and that some of the theories and research could be eliminated because they had become outdated or had not received experimental support, thereby reducing the dissonance in the literature. Although there is still much that we don't know in this area, plausible conclusions based on the information that is currently available can be made.

This book was written with a broad audience in mind—bright undergraduates and graduates and their professors and general readers who are intrigued with the questions and answers about cognitive sex differences. It could serve as a supplemental book in many courses in psychology and other fields. The other issues raised in this book are appropriately addressed in introductory psychology, sociology, education, philosophy, human development, and biology courses. It is also appropriate for advanced courses in sex roles, sex differences, human genetics, child and adult development, education theory and research, social psychology, and physiological psychology because of the broad perspective needed in understanding cognitive sex differences.

The topics addressed vary in their complexity, with brain-behavior relationships more difficult to explain than psychosocial influences on the development of cognition. My goal was to make even the advanced topics in biology and statistics comprehensive without oversimplifying multifaceted relationships or losing sight of the fact that the problems are complex. The topics addressed in this book go far beyond the usual “pop” coverage found in the popular press. I hope that despite my efforts to emphasize serious research and conceptual issues I have been able to convey to readers some of my fascination with one of the most controversial and politically charged topics in modern psychology, the psychology of cognitive sex differences.

Why Should We Study Sex Differences in Cognitive Abilities?

Introduction and Overview

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A HOT ISSUE IN CONTEMPORARY PSYCHOLOGY

The difference between male and female is something that everybody knows and nobody knows.

—John Money (1987, p. 13)

Surf through television channels, lurk on blogging sites, leaf through magazines, and peruse the scientific and scholarly journals—it won't be long before you come across a joke, an outrage, or a serious discussion about the similarities and differences between men and women. The topic is probably as old as humankind and as new as this morning's news. Yet, it continues to fascinate and confound us. Over the last four decades, observers noted that, "women have become the latest academic fad" (Westkott, 1979), the study of sex differences is a "national obsession" (Jacklin, 1989), and "articles describing the intellectual differences between the sexes have been altogether too commonplace" (Sheppard, 2006). One thing is certain: the number of publications on this topic has soared. If any readers doubt that comparisons between females and males has been a growth industry, enter sex differences or gender differences into any of the large databases in the social or biological sciences. A recent search in the mammoth database PsychINFO came up with over 86,000 entries with these terms. Of course, these numbers do not include searches in medical or biological databases, or ones that are primarily dedicated to education, sociology, or the other academic areas that are concerned with the ways in which men and women are similar and different.

But the topic of sex differences isn't just "hot" in the sense of fashionable; it is, in fact, inflammatory. The answers we provide to questions like, "Which is the smarter sex?" or "Do girls have less mathematical ability than boys?" or "Are boys unsuited for learning in traditional classrooms?" have implications for present and future societies. The questions are important, and no one is taking the answers lightly. Few areas of study engender as much controversy and acrimony as the questions about sex differences. The way we answer these questions will influence the way we live our lives and the way we govern society. It is my goal to change not only how you answer these questions, but how you ask them as well.

Perhaps the way we pose questions about sex differences contributes to the controversy and acrimony. Instead of assuming the perspective of which sex is better for a particular task or which sex has more of some hypothetical ability, there is a less polarizing approach to the many questions that society asks about the nonreproductive differences between men and women. The focus of the sex differences questions needs to change from "Who is better?" to "Where and when are meaningful differences found?" and "How can we use our findings to help all people achieve their maximum potential?"

It seems that it is not just psychologists and other researchers who are asking these questions. As shown in the next figure, even cartoon characters are wondering about the differences in the way males and females think.



HAGAR © 1991 KING FEATURES SYNDICATE.

WHY SHOULD WE STUDY COGNITIVE SEX DIFFERENCES?

Gender statistics can help eliminate gender-based stereotypes.

—United Nations Economic Commission for Europe (2009)

With tens of thousands of studies and so much interest in cognitive sex differences, it seems natural to ask, “Why should we care?” After all, what can we learn from or do about the issues raised when people study the way males and females are similar and different in their cognitive abilities?

In every area of research there are controversies about the way the research is conducted, the interpretation of the findings, and the theoretical and practical significance of the results. But, unlike many other areas, people who study sex differences face the additional and central issue of whether sex differences research *should be* conducted. Many psychologists and others are opposed to any comparisons of women and men. Much of the opposition is based on the fear that when differences are found, the data will be interpreted and misused in ways that support a misogynist agenda or unwittingly provide support for the idea that there are “proper roles” for men and women. Others have objected to the study of sex differences based on the reasoning that if we cannot do anything about differences, then why study them?

In response to the question about why we should study sex differences, the authors of a large international study responded with these points:

There are at least three reasons to study gender differences: i) to understand the source of any inequalities; ii) to improve average performance; and iii) to improve our understanding of how students learn. Gender differences point to areas where student background and characteristics significantly affect student performance. Understanding what drives differential student performance can foster the design of effective educational policies to address quality and equity concerns. Why do female and male students perform differently?

(Programme for International Student Assessment, 2009)

In considering the question of whether scientists should study sex differences, there are two fundamental questions to consider:

1. What is the meaning of sex differences? This question is at the heart of sex differences research. If we find that, on average, males and females excel at different cognitive tasks, such as reading maps or writing poetry, what does this sort of conclusion tell us? Results like these tell us about average group differences on a particular task. The most important question is what conclusions like these do *not* tell us. Studies that compare groups of males and females do not identify the smarter sex. It is important to keep in mind that *differences are not deficiencies*. People can excel at different sorts of tasks without declaring that one group is “the winner,” and the other group “the loser.” For example, in later chapters we will consider data that show that males are more likely to use a spatial strategy to solve some math problems and females are more likely to use a verbal strategy. Usually, there is a preferred or shorter method for solving math problems, but most math problems can be solved more than one way, and everyone—males and females—can learn more than one way to solve problems. Throughout this book I present evidence showing that there are some cognitive areas in which females, on average, excel, and other cognitive areas in which males, on average, excel. I did not attempt to “balance” findings that favor one sex with findings that favor the other sex, but as readers will see, there is no winning sex when it comes to cognitive sex differences.

Average differences about any group of people tell us nothing about individuals. Even if we were to conclude that, on average, girls learn to read at a younger age than boys or boys are faster at tasks that require some spatial skills, this sort of conclusion tells us nothing about you or anyone else. No one is average, so group averages should never be used to make decisions about individuals. I return to this point in several places in this book because it is so important and because there is a great temptation to reason incorrectly, for example, by finding that on average girls excel at some task; Sally is a girl; so, she must excel at that task. The ideas that there is much variability within groups and considerable overlap between groups are discussed more fully in the following chapter, but it is essential to keep this idea in mind when thinking about sex differences or the differences between any groups.

Learning about average group differences tells us nothing about the origin of the differences. There have been enormous changes in career choices, participation in different areas of education, and in family structures, over the last several decades. When research identifies areas in which there are sex differences, the conclusion is about current differences. We cannot confuse what is with what can be or what should be. As you will see, cognitive sex differences is a complex topic that defies simple answers.

2. Why are we so afraid of differences? This is an easy question to answer. We should be very cautious about group differences research because the

results of studies have been misused. Research about group differences has been used throughout history to oppress members of minority groups and to document the inferiority for any “group that is different from mine.” When the research pertains to differences between women and men, the results are almost always used to promote misogyny, although more recently, males have been labeled as the “inferior or failing” group, a trend that is described later in this chapter. Given the misuse of sex differences research, it is easy to understand the fears of those who are opposed to the research.

Despite legitimate concerns about the misuse of data, the only alternative to sex differences research is pretending that differences do not exist, which will not advance understanding or reduce prejudice. Ignorance is not an antidote for prejudice. A scientific approach to the questions about cognitive sex differences is the only way to sort fact from fiction. Ignorance does not counter stereotypes or dispel myths. If there was no research on sex differences we would never know that females earn much less than males or that males are much more likely to be diagnosed with certain mental disorders. High quality research is the only way that we can determine whether and when females and males are likely to differ. It is the only way that we can reject false stereotypes and understand legitimate differences. Censorship, even self-censorship, does not advance science or reduce prejudice.

The idea of cognitive sex differences, especially when we consider that these differences are, in part, biologically determined, is a dangerous idea for many people. In a paper on dangerous ideas, Steven Pinker (2006a) wrote that dangerous ideas are not like weapons of mass destruction or the evil ideologies of fascists or cults. He defined dangerous ideas as statements of fact or policy that can be defended with evidence and argument, and challenge the decency of people at a particular time in history. For some readers, the idea that males and females differ in their cognitive abilities conforms to Pinker’s definition of what makes an idea dangerous. In response, I believe that we cannot shy away from dangerous ideas. Ignoring critical contemporary issues will not make them disappear nor will it result in a prosocial outcome. Readers are urged to read carefully and think critically. These are the best precautions when ideas may be dangerous.

Similarities and Differences

When thinking about sex differences in cognitive abilities, the question that is usually asked is whether males and females are similar or different. Readers with a good background in critical thinking will recognize this question as a classic example of the thinking fallacy known as the “either–or fallacy.” The answer to questions about cognitive sex differences is not whether the sexes are similar or different because they are both. Females and males are similar **and** different in many ways. This answer is true regardless of whether the question is about how they solve navigation or mathematical problems, or how

they respond to social situations, or how brain structures are alike or dissimilar for males and females. Throughout this book, similarities and differences are noted, with an emphasis on how these similarities and differences are reflected in behavior and thought and the extent to which differences and similarities reflect multiple influences, such as the joint effects of life experiences and hormones, to name just two.

Some critics of research on cognitive sex differences have suggested that researchers study only similarities because an emphasis on differences will obscure the many similarities between females and males. In research, any study of differences is also, by default, a study of similarities because we cannot look for one without also looking for the other. The methods of research and data analysis are always couched in the language of differences, with the general idea of obtaining data that are so unlikely to occur when groups are similar that the researcher can reject the “null hypothesis,” which is the hypothesis that there are no differences between groups, to conclude that the groups (probably) are different. The research community has debated whether the general approach of testing and rejecting the null hypothesis of no group differences is a good way of thinking about and designing research. Although most researchers admit its limitations and offer many caveats and suggest alternatives to this approach, they also agree that it is a reasonable way of conducting research if researchers understand its limitations. The many statistical arguments for and against null hypothesis testing are beyond the scope of this book (Kline, 2004); readers can be assured that similarities are studied every time differences are studied, although we usually need different statistical tests to conclude that two groups are the same. This topic is discussed in more detail in [Chapter 2](#).

Maximizers and Minimizers

The gender similarities hypothesis . . . holds that males and females are similar on most, but not all, psychological variables.

—Janet Hyde (2005, p. 581)

The literature on sex differences in cognition is huge, and the conclusions across studies and reviews of the literature are not always consistent, even when various authors discuss the same findings. Some researchers talk about males and females as though they were alien species. In the language of a popular book on this subject, researchers who maximize differences act as though “Men are from Mars and Women are from Venus” (Gray, 1992). This book title is an extreme example of the idea that the sexes are completely different. This book has been a phenomenal best-seller, with over 7 million copies sold in 40 languages (Zimmerman, Haddock, & McGeorge, 2001). The success of books like this one is evidence that many people believe that women and men are essentially dissimilar (Prentice & Miller, 2006). Few

psychologists endorse this view, which has no solid basis in science. As others have already noted, it is more appropriate to conclude that “men are from North Dakota, women are from South Dakota” (Dindia, 2006) than that they are from different planets.

Writers who talk about differences as though a huge chasm existed between men and women are *maximizers*. In contrast, other psychologists have taken the position that females and males are mostly similar, a hypothesis that has been called “gender similarities hypothesis” (Hyde, 2005, 2006). This interpretation of the data is representative of *minimizers*. Most psychologists and other researchers fall along this continuum in the extent to which they interpret the vast research literature as supporting one view or the other.

In this book, there are many examples where people believe that there are sex differences, but in fact there are no differences, and fewer examples of sex differences that are large in size and potentially important in understanding human thought and behavior. Lippa (2006) has called this approach the “gender reality hypothesis.” I have stayed close to the data when describing and discussing the research literature on sex differences. The perception of whether one is biased toward maximizing or minimizing differences has much to do with the perception of the person making the observation. I invite readers to think critically about the data and their interpretation of the data, and to delve deeply into the many questions of cognitive sex differences with me.

THEORETICAL APPROACHES

Feminists be bold! Let us be active, smart scientists who welcome new research findings and who enter the theoretical fray as powerful contenders.

—Alice H. Eagly (1994, p. 513)

Although findings of cognitive sex differences tell us nothing about their cause, most researchers have a theory or explanation in mind which they test with their research. A theory is an explanation of some phenomenon. Theories answer the “why” questions in science. Suppose researchers found that girls are better at recognizing faces than boys are. This is not just a supposition; the data that support this finding are presented in [Chapter 3](#) (Rehman & Herlitz, 2006; Sasson, Pinkham, Richard, Hughett, Gur, & Gur, 2010). Although the relationship between one’s sex and the ability to recognize faces is interesting, without a theory that would explain this finding, we cannot understand why such a relationship exists. One likely theory to explain why females are better at remembering faces than males are is related to the finding that females are better than males at recognizing emotions as they are expressed in someone’s face (Sasson et al., 2010). Faces are easier to remember if each one is made more distinctive by the emotions that are shown.

In thinking about theories, it may be useful to understand that scientists make many observations as part of the scientific process. They create a theory that ties all of the observations together. The theory allows them to make predictions. They then design studies that allow them to test those predictions. If the results fit the theory, the more confidence we can have in the theory. If the results do not fit the theory, the theory needs to be adjusted to account for the results. Theories about sex differences are presented throughout this book. Those that are primarily biological in nature are presented in [Chapters 4 and 5](#), and those that are primarily environmental or social in nature are presented in [Chapters 6 and 7](#).

Nature–Nurture Controversy

Nature is a political strategy of those committed to maintaining the status quo of sex differences.

—John Money (1987)

Does nature or nurture play the greater part in cognitive sex differences? This is a familiar question for anyone who has seriously pondered the nature and origin of differences between females and males. When applied to differences in cognitive abilities, the question becomes controversial and politically charged. Like all loaded questions, the answers sometimes backfire. The implications of the way psychologists answer this question are similar to those about racial differences in intelligence, in that the results could be, and have been, used to justify discrimination and/or affirmative action based on sex, the need for single-sex schools, and much more.

The nature–nurture dichotomy has guided much of the research in the area of sex differences. Proponents on each side of the issue stack up their data hoping to overwhelm the opposition with the sheer weight of their evidence. Arguments on the nature side of the question point to the folly of denying that the biological manifestations of manhood and womanhood influence how we think and act. How could we deny the cumulative effects of different circulating sex hormones on the brain and behavior? The nurture side is quick to point out that individuals develop in a societal context that shapes and interprets thoughts and actions in stereotypical ways. Surely much of what we know about the way the sexes differ (outside of their complementary roles in reproduction) is learned.

Nature–Nurture Interactions

Of course, few, if any, modern psychologists maintain a strict “either/or” position on the question of nature versus nurture. The naturally gifted poet and author, for example, will never develop this gift if denied an education. The gift will never be recognized if publishers refuse to publish the creative work.

Nature and nurture must operate jointly in the development of cognitive abilities. When we say that nature and nurture interact, it means that specific combinations of each “independent variable” combine in ways that would not be predicted from either variable alone. Thus, for theoretical purposes, this model assumes that “nature” and “nurture” are independent and that certain combinations produce unusual results. For example, if you were lucky enough to receive genes for high intelligence and were raised in an environment that was favorable to intellectual development (perhaps a home with many books and college-educated parents who spent time reading to you), then you might develop into a genius—far beyond a level that would be predicted from either your nature alone (genetic inheritance) or your environment alone (intellectually stimulating home). Other specific combinations (e.g., genetic inheritance for low intelligence combined with an environment that is not conducive for intellectual development) would also be expected to be important determinants of an individual’s level of intelligence by those who support an interactionist position of nature and nurture.

Although most researchers agree that the better question is how much do nature and nurture contribute to the development of cognitive abilities, it is virtually impossible to devise measures that allow for a direct and independent comparison of these two types of influences. In addition, nature and nurture are not independent. Nature and nurture are like conjoined twins who share a common heart and nervous system. They cannot be separated. Although virtually all researchers pay lip service to interactionist positions, most of the research is, in fact, focused primarily on either biological (nature) variables or environmental (nurture) variables. We are both biological and environmental beings—our biological potential develops within an environment, despite the fact that researchers often interpret variables that influence development as being primarily one or the other. The nature–nurture controversy has been debated for over 2,000 years without resolution because it is essentially unanswerable. Yet, it has served as a framework for much of the sex differences research.

Epigenesis: Environment Affects Gene Expression

Genes are not exempt from influences at other levels of analysis but are, in fact, dependent upon them for initiating and terminating their activity.

—Gilbert Gottlieb (2007, p. 2)

Scientists have a new understanding of the way the environment controls gene expression, which makes the distinction between biological and environmental effects even more difficult to disentangle. The growing field of epigenesis is discovering how events in the environment activate or “turn on” genes. New research in epigenesis is profoundly changing the way scientists understand heredity and how some genes are “activated” in supportive and in harmful



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environments. Earlier researchers studied the way genes affect behavior in a fairly straightforward way by looking for links between genes and behaviors, but the emerging field of epigenesis has changed the route from genetic causes to behaviors. There are chemical processes that activate or suppress gene activity, which is why identical twins, who, by definition have the same genetic make-up, become increasingly dissimilar over time as they experience different environmental events. We no longer believe that genes act in ways that are independent of the environment. Gene action is not rigid; very different patterns of gene activation will occur in different environments. Although the field of epigenesis is revolutionizing scientists' thinking about genetic influences, the basic idea that environments support or fail to support the expression of different genes is not new. Scientists and just about everyone else knows that if a pregnant woman drinks too much alcohol or is malnourished, her child is likely to have life-long deficits, even if the child were born with genes for high intelligence. These advances make it clear that trying to decide what portion of some behavior is due to biology and what portion is due to environment is a meaningless endeavor. Nature needs nurture; it makes no sense to talk about these as two distinct contributions in human development.

Evolutionary Psychology

Evolutionary psychology has produced questionable results.

David J. Buller (2005, p. 277)

The nature–nurture controversy erupted into a full scale war when E. O. Wilson “sought to establish sociobiology ‘as the systematic study of the biological bases of all social behavior’ ” (Bleier, 1984, p. 15). Evolutionary psychology is a subdiscipline within biology and psychology that attempts to use evolutionary principles to explain the behavior of humans and other animals (Confer et al., 2010). It has been growing in popularity over the last several decades with adherents from several different academic domains including anthropology, history, and geography among others. The term “evolutionary psychology” has evolved as the general label for psychological theories grounded in the Darwinian principles of reproductive fitness. A major tenet of evolutionary psychology is that there are genetically programmed universal traits that improve the probabilities of producing many viable offspring. Given the basic assumptions of evolution, women, for example, should have a genetically determined predisposition that makes them better at child care because they are the ones that gestate and nurse the young of our species. Like the female members of other species, women purportedly possess a “maternal instinct” because such an instinct would be beneficial to the survival of the species.

Evolutionary psychology has enjoyed a tremendous increase in popularity in part because of research showing that women tend to prefer men who are reliable and with high social status, and men tend to prefer women who appear to be fit for reproduction (Stone, Shackelford, & Buss, 2008). Critics of evolutionary explanations for complex human behaviors argue that sex-typical responses are learned and depend on many variables in the situation.

It is probably more accurate to think of evolutionary psychology as a broad framework for understanding Darwinian-based psychological principles instead of a single, unified theory. Several different explanations have been proposed that are rooted in the idea that contemporary human sex differences have an evolutionary basis (Geary, 2010). Although each of these positions is discussed in more detail in later sections in this book, an overview of each is useful for understanding how explanations of sex differences that are offered by evolutionary psychologists differ from those that are offered from other theoretical perspectives.

Differences Between Monogamous and Polygynous Species

One theory of the evolutionary bases of human sex differences focuses on how sex differences vary across species with respect to their mating strategies. For

example, Gaulin and his colleagues (Gaulin, 1995; Gaulin, Fitzgerald, & Wartell, 1990; Gaulin & Wartell, 1990) studied sex differences in spatial abilities in two species of voles (rodents), one of which is monogamous (males mate with only one female member of the species) and one of which is polygynous (males mate with more than one female of the species). They found that only the polygynous species showed sex differences in spatial abilities. Gaulin argued that polygynous male voles have larger home ranges than monogamous male voles, because the polygynous species needs to roam further to find multiple mates. For polygynous male rodents, superior spatial skill would provide a reproductive advantage. For the monogamous species, the males and females have the same home range and, therefore, as predicted from this theory, there are no sex differences in spatial skills for these rodents. Gaulin hypothesizes that human males developed excellent spatial abilities (along with the underlying neuroanatomical structures for superior spatial abilities) during human evolutionary history because human males with these abilities, like polygynous male rodents, would be better at life skills such as hunting and finding mates and therefore have higher reproductive rates.

As further support for this evolutionary perspective, Gaulin (1995) examined the hippocampus, a portion of the brain that underlies spatial cognition (knowledge about spatial arrays and navigation through space). He reported that there are no sex differences in the size of the hippocampus in monogamous species of voles, but for polygynous species of voles, the males have larger hippocampi (plural of hippocampus) than females. Sherry, Jacobs, and Gaulin (1992) conclude that “because sex differences evolve slowly, any findings of sex differences in neuroanatomy and related cognitive function are especially strong evidence of adaptive modification of the brain” (p. 300).

Recent studies with rats support the general idea that the polygynous species show sex differences in spatial behaviors (Saucier, Shultz, Keller, Cook, & Binsted, 2008). In one study, male rats were better able to navigate through unfamiliar space (in this study, they used a water maze in which an animal needs to find its way to a safe platform while swimming in an opaque container), and female rats were better at remembering which objects had been moved in an array of many objects. The authors reasoned that rats did not use different verbal strategies (because rats do not use language), which has been hypothesized as a possible reason for similar findings with humans. Therefore, they argued that the similar finding for rodents and humans on spatial tasks likely reflects the effects of evolutionary pressures. Although much more research is needed to determine if sex differences in other animal species are correlated with whether the males have a large or small home range or whether the species is monogamous or polygynous, humans are obviously more complex than rodents, so we have to be cautious when drawing conclusions between the two. It also seems that this explanation would require the assumption that humans are more like a polygynous species of rodent than a monogamous one.

The Hunter-Gatherer Hypothesis

Generalizations to human behavior from our closest relatives ignore
5 million years of exuberant evolutionary development of the human brain.
—Ruth Bleier (1978, p. 161)

Although evolutionary psychology may be best fit for understanding human mating preferences and behaviors, it has been extended to cognitive sex differences. Geary (2004, 2008) made a distinction between those cognitive skills that are “primary,” that is they were shaped by evolutionary pressures and therefore would be found across cultures and developed universally in children’s play, and those skills that are “secondary,” that is they are found only in technologically complex societies—skills like reading and spelling that are important in school, but would not have evolved in hunter-gatherer societies. Geary maintains that there are no sex differences in biologically-primary mathematical abilities such as counting or understanding basic concepts in comparing quantities. According to Geary, sex differences are found only in those mathematical abilities that are biologically secondary, abilities like solving mathematical word problems and geometry. These academic skills must be deliberately taught and practiced. He suggests that sex differences in spatial cognition could be the underlying factor in explaining the differences that are found in some types of math problems.

In later chapters I discuss the common finding of sex differences in navigation strategies. Evolutionary psychologists believe that these differences have evolved over time and reflect sex differences in hunter-gatherer societies in which men traveled far from home in search of animals to hunt and kill, and women stayed closer to home in their role as caregivers and plant gatherers. There are numerous thoughtful critiques of evolutionary psychology (Halpern et al., 2007a), including the idea that virtually any finding can be explained by hypothesizing how it might have been advantageous to hunter-gatherers. For example, Newcombe (2007) and Halpern (2008) countered the argument that hunter males would be particularly likely to be selected for spatial skills by arguing that women in hunter-gatherer societies also had to travel long distances to gather edible plants that ripened in different locations in different seasons of the year. Women also had to move their living sites with the seasons and many of the manual tasks that women performed in these early societies were highly spatial in nature, such as basket weaving, which was essential for gathering food, and making cooking vessels and other household goods. Although no serious scientist doubts the basic premises of evolution, or the basic idea that the human brain evolved, many find fault with the idea that all sex differences can be explained by citing a possible evolution-based explanation. Others have argued that evolutionary psychology is just beginning to make progress in understanding individual differences and that current criticisms regarding its inability to explain cultural variations will likely be answered as more researchers adopt the perspective of evolutionary psychology (Confer et al., 2010).



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Biopsychosocial Hypotheses

Of all the discoveries that have poured out of neuroscience labs in recent years, the finding that the electrical activity of brain cells changes the physical structure of the brain is perhaps the most breathtaking.

—J. Madeleine Nash (1997, p. 10)

Biopsychosocial hypotheses offer an alternative conceptualization to the nature–nurture dichotomy, to the interaction of these two forces, and to evolutionary theories that posit Darwinian adaptation by our prehuman and early human ancestors as the reason for contemporary sex differences in humans. (In earlier editions of this book, I used the term psychobiosocial to indicate the primacy of psychological processes in shaping people, but the more usual term in the literature is biopsychosocial, so I am using the more usual term in this edition.)

The biopsychosocial hypothesis is based on the idea that some variables are *both* biological and social and therefore cannot be classified into one of these two categories. Consider, for example, the role of learning in creating and maintaining an (average) difference between females and males. Learning is both a socially mediated event and a biological one. Individuals are predisposed to learn some topics more readily than others. A predisposition to learn some behaviors or concepts more easily than others is determined by prior learning experiences and the neurochemical processes that allow learning to occur (release of neurotransmitters) and changes in the structure of the brain in response to learning (e.g., long-term potentiation and synaptic changes in areas of the brain that are active during performance of a task; Posner & Raichle, 1994). Thus, learning depends on what is already known and on the neural structures and processes that undergird the learning and remembering processes. Of course, psychological variables like interest and expectancy are also important in determining how readily information is learned, but interest and expectancy are also affected by prior learning. The model that is being advocated is predicated on an integral conceptualization

of nature and nurture that cannot be broken into nature or nurture subcomponents. Neural structures change in response to environmental events; environmental events are selected from the environment based, in part, on predilections and expectancies; and the biological and socially mediated underpinnings of learning help to create the predilections and expectancies that guide future learning.

Instead of perceiving nature and nurture as “independent variables,” biopsychosocial hypotheses recognize that nature and nurture are inextricably entwined. Biology responds to the environment and people adjust and select their environment to make it compatible with their biological propensities. Consider the biological question of whether male and female brains tend to differ in their organization of functions, a topic that will be discussed in considerable detail in later chapters. Brain differences develop in the context of a socialization process. The architecture of the brain is “established early in life through a continuous series of dynamic interactions between genetic influences and environmental conditions and experiences” (Fox, Levitt, & Nelson, 2010, p. 28). In a classic study, Diamond (1988) found that when rats were reared in either enriched or impoverished environments, their brains manifested systematic differences in cortical thickness and weight, the branching of dendrites (parts of the neurons), number of glial cells (nourishing tissues), and cell size. Furthermore, even in old age, the brain was altered in response to changes in the environment. The brain has an enduring capacity to form new synapses (connections; Greenough, 1986; Greenough, Black, & Wallace, 1987). A newborn’s early experiences will determine the vast majority of the 1,000 trillion synapses (connections) among the billions of neurons (Lach, 1997). Thus, even if we were to conclude that there are structural differences in male and female brains, we could not know whether such differences were due to sex-related biological mechanisms or occurred as a response to a socially differentiated environment or, as is more likely, some combination of the two. In other words, were we born that way, did our experiences change our brain, or both?

The turbid relationship between nature and nurture is muddled even further when we consider that the links between cognitive performance and its underlying biology are only loosely conceptualized. All behavior results from the joint action of biological, psychological, and social influences. Suppose that testosterone has an influence on the brain such that males have a slight advantage on spatial tasks, such as playing with building blocks. Because of this slight advantage, males look for more opportunities to use those skills, such as playing baseball, soccer, or football. Family, peers, society in general, then label those particular activities as male-appropriate. As males further engage in such activities, their spatial skills continue to build. What was initially a small difference between males and females is now a large difference. When viewed from a biopsychosocial perspective,

the same variables are both cause and effect. Brain alterations result from different life experiences and different genetic propensities and they affect future behavior which, in turn, influences further brain development. This circular pattern is depicted in [Figure 1.1](#). In this way, biological, psychological, and societal factors could operate in concert to enhance an initially small between-sex difference. Similarly, they could also reduce an initially large between-sex difference.

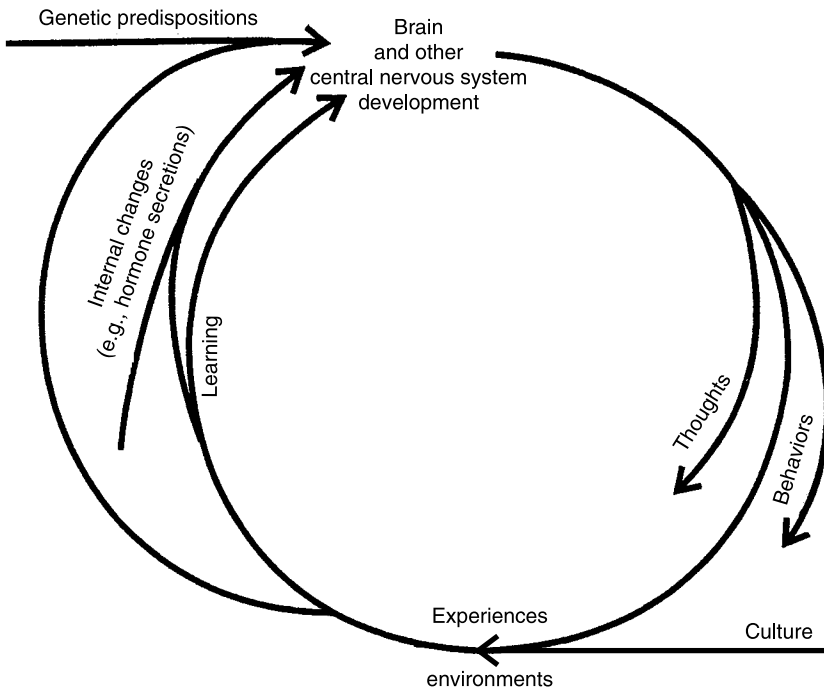


Figure 1.1 A schematic diagram of a biopsychosocial model in which nature and nurture are continuous and inseparable. Notice that thoughts and behaviors, which are biologically mediated processes arising from brain activity, can alter the environment experienced by individuals, which in turn can alter brain development and other internal processes (e.g., hormone secretions). Genetic potential also can be affected by environmental stimuli (e.g., some drugs), causing changes in biological processes (e.g., signs of aging), which in turn can alter the environmental experiences to which each individual is exposed. Note also that cultural variables (the social part of the model) can create differences in the brain and other biological systems. The experiences that people have throughout life can create, reduce, or magnify sex differences in the biology of males and females.

The Importance of Place and Time

A weekday edition of *The New York Times* contains more information than the average person was likely to come across in a lifetime in 17th century England.

—Richard S. Wurman (2001)

A sociohistorical perspective is needed to understand any complex question, like the ones about cognitive sex differences because the data we use to answer these questions will depend on where and when they were collected. Certainly the society in which people live has a profound influence on how people develop their cognitive abilities. Consider, for example, that one of the first acts the Taliban took when they assumed power in Afghanistan in the 1990s was to ban all education for girls older than 8 years old. In 1996, all women were banned from employment and, unless they were fully covered, women could not be seen by anyone outside of their immediate family (U.S. Department of State, 1998). It is not difficult to imagine that after only a decade or so of these decrees the women in Afghanistan would seem to have little intelligence, at least when assessed with any of the standard measures. Their intellectual abilities would never be allowed to develop.

The historical period in which people live will also provide a context for understanding how they think and learn. We are living at a time when information is accumulating at an unprecedented rate. A college degree is needed for most of the fastest growing jobs in our economy, which means that every generation needs more education than the previous one. Flynn (1987) showed that intelligence scores have been rising from one generation to the next and that this increase is occurring in multiple countries around the world. He believes that the ultimate cause for these gains is the Industrial Revolution and with it education for the masses that grows more sophisticated every year (Flynn, 2009). College-going rates have increased over the last five decades for both men and women, with women attending college at a higher rate than men since the mid 1980s. Changes over time for college attendance for men and women in the United States are shown in [Figure 1.2](#).

Abilities are developed in multiple ways, especially with education, so it is not surprising that adults at the start of the 21st century have more knowledge and the ability to use their knowledge than earlier generations. It is also expected that the children of today's adults will continue the general rise in intelligence so they will become more intelligent than the adults of today. Thus, when thinking about sex and cognition, we need to recognize that societies and historical periods will significantly affect the conclusions that we can draw.

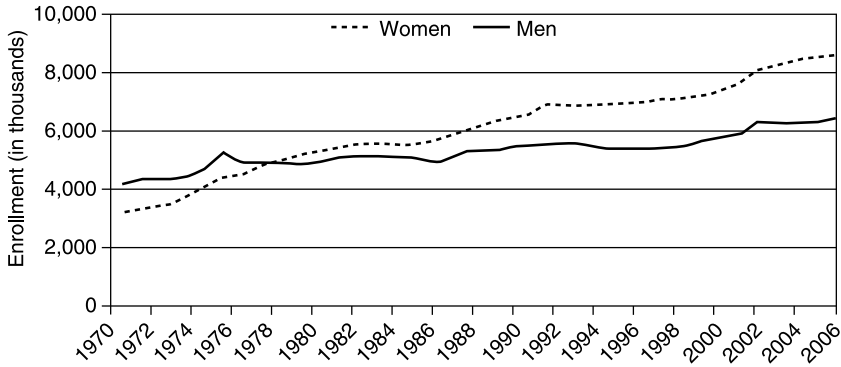


Figure 1.2 College-going rates for women and men in the United States between 1970 and 2006. Note that the rate has increased steadily for both men and women over the 36-year period shown in these data, but it has increased faster for women. From U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (2006).

THE NOTION OF COGNITIVE ABILITIES

Cognitive psychology is the branch of psychology concerned with how people think, learn, and remember. The ability to think, learn, and remember is, in turn, related to the concept of intelligence. Although intelligence has been defined in many ways (see Halpern, 2003; Neisser et al., 1996; Nisbett et al., under review), it is used in this context as the raw material or “stuff” of thought. It is frequently conceptualized as a limited quantity within each individual that is developed more or less fully depending on environment. Intelligence is “a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts” (Gottfredson, 1997, p. 13).

Intelligence—Singular or Plural?

One view of intelligence is that there is a single “general” factor, known in the literature as “*g*” for short (Spearman, 1927). This approach is contrasted with the view that intelligence is made up of a number of separable factors (Thurstone & Thurstone, 1941). The debate over the structure of intelligence, which is whether it is best conceptualized as a single factor or composed of several components that are relatively independent of each other, may be among psychology’s longest-running and most acrimonious controversies.

The research literature that addresses the question of whether it is more accurate to think of intelligence as a single or multifaceted trait spans the last 110 years and shows no sign of abating. There is some evidence that intelligence can be thought of as a general trait, at least for some purposes, but there is also good evidence that there are separable components or cognitive abilities. At the heart of the intelligence controversy are methodological issues such as how to best define and measure intelligence. The research literature shows that there are differences in the ability to reason abstractly and to process information accurately and quickly, and that, when we examine performance on complex tasks, meaningful, separable factors emerge. But, it is also commonly believed that the factors that make up intelligence are all related to a single “intelligence.” In an extensive review of the literature, Brody (1992) concluded that “the structure of ability tests supports a hierarchical model of ability with *g* at its apex” (p. 49). Thus, he concludes that intelligence is comprised of a single factor that can be broken down into separable components—sort of a compromise position between the single-factor and multiple-factor theorists. Many contemporary psychologists believe that intelligence is not a unitary concept, although there is considerable disagreement as to the number and nature of the separable factors (Canivez, Konold, Collins, & Wilson, 2009; Sternberg, 2006).

It is constructive to think of intelligence as comprised of several intellectual abilities that are related to each other, but yet somewhat different. The number and nature of these component abilities are frequently identified with a mathematical procedure known as factor analysis. Factor analysis is a useful descriptive technique that allows researchers to discover clusters of correlated variables. Intelligence was one of the first interests of early psychologists, and there is probably more written about intelligence than any other topic in psychology. In a classic factor analytic study of intelligence, Thurstone and Thurstone (1941) administered 60 different ability tests (e.g., arithmetic, spelling) to eighth grade students. They found that scores on these tests formed three sets of clusters or factors which they called verbal, number (quantitative), and perception (visual-spatial) factors. Modern psychologists concerned with cognitive sex differences still refer to these same three factors.

An influential conception of intelligence was posited by Gardner (1983). In his seminal book, *Frames of Mind*, Gardner proposed seven different intelligences: linguistic, logical-mathematical, spatial, musical, bodily-kinesthetic, interpersonal, and intrapersonal. Gardner relied on multiple sources of evidence that these are seven distinct components of intelligence, or, as he calls them, “frames of mind.” Each of these seven abilities responds selectively to localized brain damage (suggesting localization of brain function). There are autistic savants who excel in only one of these areas and are dysfunctional in the other areas, and exceptional prodigies with extraordinary ability in only one of these areas. These abilities are differentially valued in different societies, and they conform to commonly-held intuitive notions about the way people differ.

There undoubtedly are sex differences in bodily-kinesthetic ability, but, like the other “intelligences,” the nature of these differences must depend on the way bodily-kinesthetic ability is measured. If we were to consider the complex graceful movements of ballet dancers, we would find that although there are numerous outstanding male ballet dancers, the vast majority of accomplished ballet dancers are female. On the other hand, if bodily-kinesthetic ability is assessed as running speed or ability to “pass” a football, then males would appear more talented. There are also some areas of bodily-kinesthetic ability in which males and females have similar levels of performance such as long distance swimming. Thus, it seems that females and males may excel at different types of bodily-kinesthetic performance depending on an interaction of physiological capacity and the opportunities provided by society for fully developing one’s potential. Bodily-kinesthetic ability is a good example of two points that I emphasize repeatedly throughout this book—the evidence available suggests that there are sex differences, but (1) there is considerable variability within each sex, and (2) it would be useless to try to decide which sex is “better” at tasks that require bodily-kinesthetic ability because on average females perform better at some of these tasks and males perform better at other types of tasks. The fact that differences probably exist does not mean that one sex is the “winner” and the other is the “loser.” Differences do not require a value judgment.

Interpersonal intelligence is defined as the ability to determine the moods and motivations of others. By contrast, intrapersonal intelligence is knowledge of one’s own feelings and motivation. It seems reasonable to conclude that there are sex differences in these areas as well. In a recent review of the literature on nonverbal communication (one measure of understanding the moods of others), Hall and her colleagues (Hall, Roter, Blanch, & Frankel, 2009) concluded that women, on the average, are better at decoding nonverbal communication. Intrapersonal intelligence is more difficult to assess because only each individual knows her or his own feelings. Common stereotypes reveal the belief that women are “more in touch with their own feelings than men are with their own feelings,” but there is very little research on this topic. Much of this book will review the literature pertaining to three measures of intelligence: linguistic (or language), logical-mathematical (or quantitative), and spatial because they are the most important cognitive domains for the complex tasks of modern life such as reading, solving problems numerically, and understanding spatial displays such as maps.

Assessment of Cognitive Abilities

Underlying abilities are abstract constructs. Cognitive abilities are the underlying abilities that psychologists believe they are measuring when they administer certain tests. But not all tests measure abilities. In fact, it is very difficult to devise a test of ability that is not also measuring achievement. An achievement test measures what an individual knows (and is willing to reveal) at the time of

the test. For example, if I wanted to know how much mathematics you know, I would give you a mathematics achievement test. If you had very few mathematics courses in high school, then I would expect that you would not know much about the type of mathematics taught in the high school courses you did not take. You would not be able to solve trigonometry or calculus problems, for example. This does not mean that you could not solve these problems with appropriate instruction, nor does it necessarily mean that you would have difficulty learning these mathematical concepts. A low score on this test would mean only that you cannot solve the mathematical problems at the time of the test.

Ability tests attempt to assess the likelihood of your being able to succeed at certain tasks in the future if you received proper instruction and if you were motivated to learn and demonstrate the skills needed to perform the task. A low score on a mathematical ability test, for example, is meant to imply that you are less able to learn certain advanced concepts such as calculus or other higher mathematics than someone obtaining a higher score. It can be loosely thought of as the ability to benefit from instruction in a certain area.

There are, however, several important “ifs” in ability testing. Suppose, for example, a young man who believes that language fluency is a “girly trait” is tested in the area of verbal ability. He certainly would not be motivated to perform well on this test, leading the researcher to conclude that he had little verbal ability. Consider some of the other assumptions implicit in ability testing. We test mathematical ability by presenting individuals with mathematical problems to solve. Wouldn’t someone who had taken more or better mathematical courses be expected to answer more questions correctly than someone with a poorer mathematical education background? In other words, aren’t we also measuring achievement? To some extent, we are always measuring achievement whenever we try to measure ability. This is a troublesome problem for psychologists who want to understand possible sex differences in ability. In American and other western societies, girls used to take fewer advanced mathematics courses than boys, but in recent years the percentage of girls and boys in advanced high school and college math courses is close to equal. In fact, slightly more girls than boys are enrolled in geometry and algebra with slightly more boys than girls enrolled in calculus (U.S. Department of Education, 2004). Achievement in these areas is measured in the United States with the National Assessment of Educational Progress, which is known as the Nation’s Report Card. Not surprisingly, recent studies show that boys and girls get similar scores on math and science achievement tests in high school in the United States. [Figure 1.3](#) shows NAEP scores in mathematics and science in 2005.

How can we ever separate the ability to succeed in math and science from achievement that results from educational experiences? We can’t. The blurry distinction between ability and achievement means that we have to be very careful about the conclusions that we draw from tests that show sex differences.

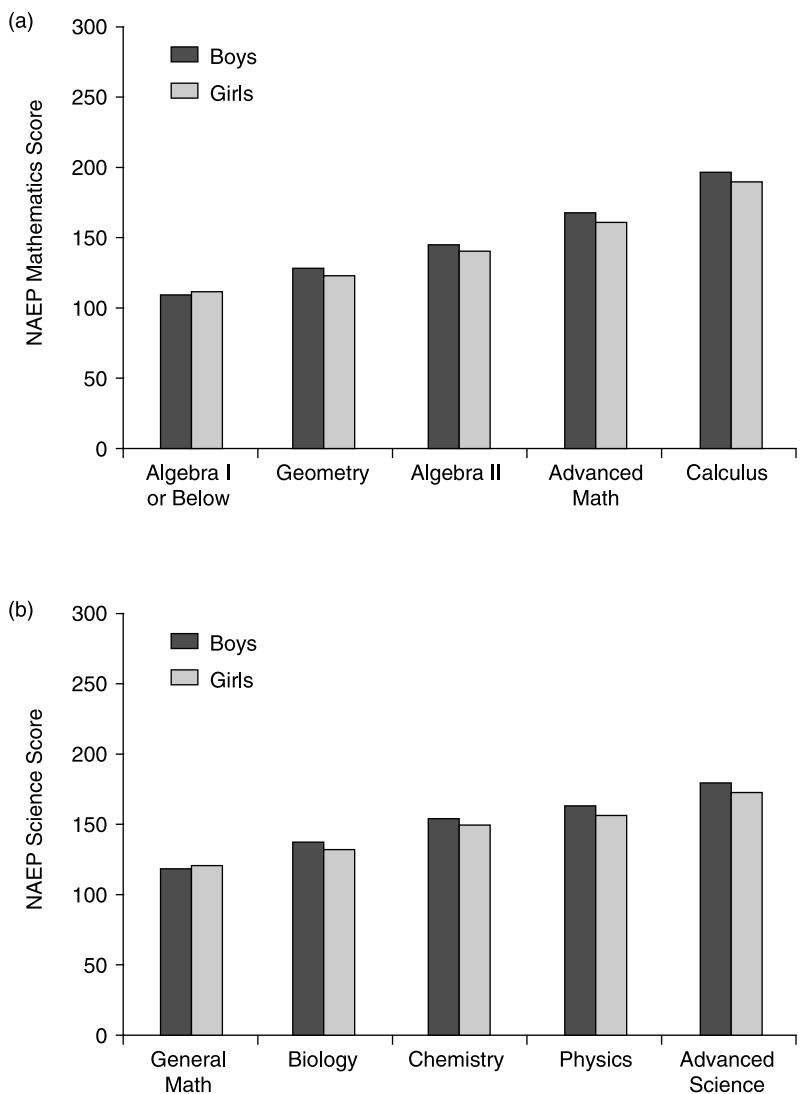


Figure 1.3 Scores for boys and girls on the National Assessment of Educational Progress (NAEP) in 2005. NAEP is known as the Nation's Report Card. These data show few differences between girls and boys in mathematics (a) and science (b). From U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (2005).

A pure measure of cognitive ability would separate what each of the sexes in fact do (achievement) from what each of the sexes can do (ability). This is not possible. Instead, we must rely on the only available data that we have. But, we also need to be careful about the kinds of extrapolations we make from it. Just because tests given in the 1980s or 1990s or into the single digit decade of the 21st century show sex differences doesn't mean that tests in the year 2015 or beyond will. The term "cognitive abilities" is used throughout this book because it is the term that is commonly used in the literature, but readers should not hesitate to question whether ability or achievement is actually being measured.

Tests of cognitive abilities, like all tests, contain a "margin of error." That is, the scores on these tests are not perfectly accurate in terms of predictions that can be made. Scores on a good test of mathematical ability, for example, should predict fairly well an individual's ability to acquire mathematical concepts. Ideally, the test should be validated by actually comparing scores on the test with achievement in future mathematics courses. But, even an ideal test would be fraught with problems because any student's future performance will depend on multiple variables, such as the quality of the course instruction, the student's effort, and a host of other factors. More often, tests are validated by comparing scores on one mathematical ability test with scores on another mathematical ability test. If, in general, the scores are in accord, we can probably conclude that they are measuring the same construct (same abstract ability), but we still cannot say much about the predictive value of either test or the meaningfulness of the construct we have just measured. The construction of valid and reliable tests is a complex statistical endeavor. Some of the tests cited in the cognitive sex differences literature have poor or unknown psychometric properties (statistical properties including reliabilities and validities). These tests should be considered only as ancillary evidence for or against a particular position and not as primary evidence because of the questionable nature of their construction. A good test measures what it says it measures (e.g., mathematical ability) and predicts how well someone will perform that skill later. Unless we have evidence that a test is measuring what it says it is, and we actually see how well it predicts, we have to be wary of the test.

In all psychological measurement, there is always a gap between the test result and what it signifies. Test results are interpretable only to the extent that a plausible theory can link them to meaningful constructs. Although mountains of data exist that address the questions of cognitive sex differences, there are few good theories that can synthesize and interpret the empirical results. Thus, while we can talk about sex differences on various tests, we cannot always interpret what these differences mean.

Cognitive abilities are theoretical constructs that represent the underlying components of intelligence. The quality of a construct in the sex differences literature can be assessed by how well it passes three tests: (1) If sex differences are found consistently on several different tests that tend to cluster

together, then we have reason to believe that, in general, the sexes perform differently on whatever these tests are measuring. This first step provides converging evidence from several tests that sex differences exist with respect to the construct being measured. (2) If, in addition, we can use these tests to predict performance on a task that requires the skills we believe that the tests are measuring, then the construct is useful. (3) If an empirically supported theory or theories have been devised to explain why sex differences exist in the ability being measured, then the construct and the theory that incorporates it have explanatory power. The ability to explain and predict phenomena is a major goal of research. The third requirement is needed to make the construct theoretically meaningful, and is the most controversial and difficult of the conditions to satisfy.

VALUES AND SCIENCE

We do not have to ask for the head circumference of women of genius—they do not exist.

—Bayerthal (1911, cited in Janowsky, 1989, p. 257)

Political and ideological positions are intertwined when psychologists and others venture into studies of group differences of any sort. The question is not whether individual and societal beliefs influence the scientific methods, but when, how, and how much.

The Myth of Objectivity

All knowledge is constructed and the knower is an intimate part of the known.

—Mary Belenky, Blythe Clinchy, Nancy Goldberger, and
Jill M. Tarule (1986, p. 137)

When most of us first learned about the scientific method, somewhere back in junior high school, we were told about the disinterested researcher who objectively and methodically goes about the business of collecting data with the goal of revealing truth. For those of us involved in research, the imagery that this description brings to mind is somewhat humorous. Although it is true that researchers collect data, very little of what most of us do could be considered “disinterested.” Whatever the topic, few researchers who invest their energies in an experiment are neutral with respect to the type of outcome they expect or want. This is especially true in an area like cognitive sex differences, where there is so much at stake and where the potential for misinterpretation and misuse of experimental outcomes is so great.

There are numerous ways in which personal beliefs and values can influence the experimental procedure. Researchers make many decisions in the course of conducting an experiment and the way the decisions are made can deliberately or unwittingly bias the results. Although this topic is covered more extensively in [Chapter 2](#), let's think about a few of these decisions now: the question under investigation; the traits and abilities that are assessed (e.g., visuospatial memory, interpersonal skills); the way subjects are selected (e.g., developmentally disabled as well as normal subjects); the type of measurement employed (e.g., continuous or discrete); the kinds of items used on tests (e.g., multiple choice or essay); how the data were analyzed (e.g., multivariate or univariate, parametric or nonparametric tests); the number of subjects included in the study; and whether the discussion is focused on significance levels or effect sizes.

If I were interested, for example, in showing that there are no sex differences in mathematical ability, then I would want a sample in which women with high mathematical ability were included because I would want an overall high score for the women. I could opt for discrete measurement; the test items that I would select would have to include examples drawn from typical female experiences; I could use nonparametric tests which are typically less powerful (less likely to reveal group differences); and I would want to use a small number of subjects. Decisions concerning what to focus on in the discussion could be made post hoc depending on whether they would support or detract from my favored view. None of this is dishonest, assuming that the researcher describes the way the sample was selected, data were analyzed, tests were selected and so on (although the use of a less powerful or inappropriate statistical test is very close to dishonest), nor are all of the decisions devious, especially if all of the relevant information is provided in the write-up of the experiment. In fact, the decision to include test items from typical experiences of girls would make it a fairer test than including examples exclusively from typical boy activities. This discussion is not intended to show that research or researchers are "bad." An experiment is the most objective method for providing answers to questions. It is important to keep in mind, however, that even our most objective method can be slanted in ways that support the researcher's favored outcome.

In a discussion about the relationship between values and science, Wittig (1985) stated: "Knowledge about behavior is constructed, not merely deduced. Such constructions are affected by the historical, personal, social, and cultural context. Judgments of the meaning, validity, and usefulness of a particular analysis of human behavior are themselves socially influenced" (p. 803). It is important to remember that research is conducted in a social environment. The kinds of questions that we ask and the kinds of evidence we are willing to accept depends upon their compatibility with the prevailing social view and each researcher's personal views on the topic.

In Shields' (1980) cogent discussion of the subservience of science to social values, she explained that the 19th century belief that women were

intellectually inferior to men because of the smaller frontal lobes in their brain was replaced later in the century with the belief that the parietal lobes were the true seat of intellectual prowess. Not surprisingly, the following report was published soon after the discovery of the importance of the parietal lobes: “the frontal region is not, as has been supposed, smaller in women. . . . But the parietal lobe is somewhat smaller, a preponderance of the frontal region does not imply intellectual superiority . . . the parietal region is really the more important” (Patrick, 1895, cited in Shields, 1980). Although we need to be knowledgeable about the research method in order to be able to judge the quality of any research, we also need to remember that the experimental method is the least biased way of collecting information.

Feminist Scholarship

Feminism is a perspective, not a method or a topic.

—Mary Crawford and Ellen Kimmel (1999, p. 3)

In recognition of the fact “that science played handmaiden to social values” (Shields, 1975), several psychologists have suggested that sex differences researchers adopt a “feminist scholarship” approach. One of the goals of feminist scholarship is the recognition and elimination of the “androcentric bias in both content and method” in traditional research (Lott, 1985). Men and women who ascribe to the philosophy of feminist research are careful to consider the importance of context or situational variables as potent influences on the results they obtain from research. Sex is not only a subject variable, it is also a stimulus variable, when viewed from this perspective. Women and men may respond differently in certain situations because the other people in that situation are responding to them in a sex differentiated manner. In other words, women may perform differently from men on a certain type of task because the other people in the setting are giving them more or less encouragement to perform that task than they are giving to the men.

Feminist research is based on the belief that the world is determined by the categories that we use to define it (Unger, 1989). It recognizes the role of values in research and is deliberately grounded in feminist values (Crawford & Kimmel, 1999). Feminist psychologists reject the idea that a distinction can be made between what is being studied and the person doing the study; they emphasize the notion that the beliefs of the researcher influence the way abilities and traits are interpreted (McGrath, Kelly, & Rhodes, 1993). For example, if you believe that women are more likely to gossip than men, then you will interpret objectively identical behavior by a man or woman differently—the man’s behavior is less likely to be labeled as “gossip” than the woman’s behavior. Feminist scholarship is generally skeptical about knowledge because “while it claims to be universal and objective, it is in reality based on knowledge primarily from men’s lives” (Tickner, 2005, p. 2177).

Feminist psychology has a “new” masculine counterpart as the psychology of men. “Men’s studies” is emerging as an academic area worthy of study in its own right (Doyle, 1995). One of the more recent divisions (interest areas) of the American Psychological Association, the largest professional association for psychologists, is “Psychology of Men.” “Promasculinists,” like their feminist counterparts, tend to emphasize the importance of context when thinking about the ways in which males and females differ and are the same. There is no single “men’s movement” any more than there is a single feminist perspective on complex issues. In many ways, the two perspectives are complementary in that they emphasize social and cultural factors that perpetuate male and female roles.

Advocates of feminist scholarship and the newer “promasculine scholarship” utilize nontraditional methods, such as personal reflection, in addition to traditional mainstream methods to examine qualitative differences in the psychology of maleness and femaleness. They will sometimes prefer lengthy individual interviews in attempting to understand a phenomenon. Feminist and promasculine scholars of both sexes are concerned with similarities as well as sex differences. In a survey of feminist psychologists, Ricketts (1989) found that they tend to prefer external or social determinants of human behavior rather than internal or biological determinants. A feminist approach also contains a conscious awareness of the way sexist assumptions and other stereotypic beliefs guide the kinds of research questions that are investigated and the varieties of evidence researchers are willing to accept. Like all good researchers, feminists examine the quality of the data that are collected and the logic that links the data to a conclusion. Of course, they are no freer from their own personal biases than researchers with other belief systems, but hopefully they are more aware of them and attempt to state them explicitly for others to examine—an important fact in itself.

Two Elephants in the Room

An elephant in the room is an allusion to some obvious truth that is being politely ignored. When the topic turns to cognitive sex differences, the elephants in the room are the ideas that men really are smarter than women and the exact opposite, which is the idea that women really are smarter than men. We can talk about “differences” and pretend that the discussion is not really about which is the smarter sex. For example, the volumes written in recent years about why women are underrepresented in the STEM fields (science, technology, engineering, and mathematics are the STEM fields) will often “dance around” the elephant—the idea that women are just not smart enough to become top-notch scientists and mathematicians.

For many decades, researchers concerned with cognitive sex differences focused on the underachievement of girls and women. As an example, reports began to emerge in the 1980s and 1990s that girls were being

shortchanged in schools (e.g., American Association of University Women, 1992; Sadker & Sadker, 1985). A few years later, news articles were pointing to recent research to demonstrate a “boy crisis” (e.g., Leving & Sacks, 2006). Teachers and parents were told that teaching methods needed change to accommodate the short attention spans and “natural” need for high levels of activity for boys (Gurian, Henley, & Trueman, 2001). News magazines announced “The new gender gap” (Business Week, 2003) and “The trouble with boys” (Tyre, 2006). This is an interesting twist for people who have been touting the intellectual inferiority of girls and women (e.g., Lynn & Irwing, 2008). Despite all of the public hype over which sex is winning, it is important to keep in mind that there is no competition. Our goal as parents, educators, and concerned citizens is to help every person achieve his or her highest potential. By pitting the sexes against each other as in an intellectual tug-of-war, ordinary people become combatants and those on the sidelines pick the side for which they will cheer. This is not a productive way to enhance human cognition.

I return to these important questions about male and female academic success at the end of this book. The data are complex, and the conclusions need to consider a wide range of variables. There is much room for improvement in the way we educate girls and boys, but few data that support the idea that they are so different that they need separate educational experiences.

A Question About Answers

In thinking about the nature of explanations, I caution readers not to expect simple explanations for phenomena as complex as sex differences and similarities in human cognition. Most readers will prefer a single and simple answer—especially if you are reading this book as part of an academic course where you are also concerned with putting a “right answer” on a test or paper. But there may not be a single “right answer,” or if there is, it may not be the kind of answer that you are expecting. I always tell my own students that all complex questions in life have exactly the same answer. The correct answer is “it all depends.” They like the part where they can use the same answer on every essay question in every class. The only problem with this answer is that you then have to explain what “it” depends on. When do different sorts of variables affect cognitive abilities, can differences be eliminated or magnified with experience, are there any meaningful differences, and why are these important questions to explore? Each of these many questions will have different sorts of answers and explanations. The ability to cite evidence for many sides of controversies and to understand how each might be part of an answer is a hallmark of advanced understanding. I return to the question of answers again at the end of this book. But, be forewarned: Do not expect simple answers to the many complicated questions about sex differences in cognitive abilities.

POLITICAL AND SOCIAL RAMIFICATIONS

As an area of research, sex and gender is fraught with dilemmas and decision points.

—Kay Deaux (1985, p. 74)

There are many commonly held stereotypes about differences between females and males. For example, in a study of teacher perceptions of high and low achieving girls and boys, researchers found that low achieving boys and high achieving girls conformed to the teachers' expectations. The teachers largely ignored the low achieving girls, and the high achieving boys were seen as a challenge to the teachers' beliefs (Jones & Myhill, 2004). The researchers found that when the teachers were asked directly if they expected similar achievement for boys and girls, 80% said that they did, but when they were describing the achievement of girls and boys, the teachers gave stereotyped responses such as "girls settle down and get on with it", "boys don't like writing" (p. 553), and "boys don't like to read as much as girls do." Even when the teachers were presented with information about both high and low achieving girls and boys where there were little or no differences between the girls and boys, the teachers gave polarizing statements about girls and boys. We know that teachers sometimes act in ways that convey these beliefs to the children in their classrooms (Sadker & Sadker, 1985). Suppose that after a careful review of the literature, these stereotypes were found to be true—girls really do settle down faster and boys don't like reading! (In fact, a recent international study of 15-year-old students found that although girls did spend more time reading books and magazines—1.5 hours versus 1.3 hours a week, boys spent more time reading on the internet—1.0 hour versus 0.9 hour, so any real differences are minute; Mullis, Martin, Kennedy, & Foy, 2007). Teachers would knowingly or unknowingly increase the way they encourage and discourage different areas of intellectual development in their students depending upon the student's sex. Advocates of sexual prejudice and discrimination could justify their beliefs and actions by an appeal to scientific findings. The social and political ramifications of such conclusions cannot be ignored.

SETTING THE CONTEXT: SOME STATISTICS ABOUT SEX DIFFERENCES

My parents told me to keep coming to school even if I am killed. . . . The people who did this to me [threw acid in her face] don't want women to be educated. They want us to be stupid things.

—Shamsia (an Afghani school girl, quoted in Filkins, 2009)

The political climate with regard to the questions of sex differences and the appropriate roles for men and women has been combative since the late 1960s when the Women's Movement began shaking up society in many countries around the globe. To set the stage for the coming chapters, let's consider some areas where the sex differences are indisputable so that our consideration of cognitive sex differences can take place in the broader context of the lives of men and women.

Child Care and Household Chores

During the intervening decades since the Women's Movement began in the 1960s, women have been entering traditional male occupations at an increasing rate, men have assumed a greater role in homemaking, and recent research shows that men are spending more time with their children. Between 1965 and 2004, men have tripled the amount of time they spend in caring for their children, especially in two-parent homes, and doubled the time they spend on home chores from 15% to 30% of the total (Sullivan, Coltrane, McAnnally, & Altintas, 2009). Interestingly, women have also increased the time they spend caring for children over the same time period—time taken from other areas of their lives such as personal care, sleep, and time with friends, which reflects higher standards than previous generations for both parents when it comes to child care. Women are still doing most of the child care (two to three times the amount done by fathers), but the gap has been closing over the last half century. These data show both slow and significant changes and the fact that large disparities still exist in how much women and men contribute to housework and family. When I consider sex differences in the achievement of men and women later in this book, I return to the theme of unequal contributions in the amount of work done in the home.

The Wage Gap

A substantial wage gap exists when women and men are compared, even when taking into consideration critical variables such as education, age, and length of employment. The ratio of the annual average wages for women and men in the United States was 77.8% for 2007 (for full-time workers; Institute for Women's Policy Research, 2010). If part-time workers were included the ratios would be much lower because women are more likely to work part-time (as would be expected from the finding that women spend more time on child care and other caregiving activities and on housework). These data reflect the vast differences in women's and men's earnings across occupations. According to the U.S. Census Bureau (2005), women's earnings as a percentage of men's were 65% or less in legal occupations, sales, healthcare, and technical occupations. Thus, the actual earnings ratios depend on the occupation.

When I was in college in the late 1960s and early 1970s, many students wore buttons that read “59 cents” as a symbolic reminder of the amount that women were paid for every dollar men were paid. These pins are now out-of-date, but the gap has closed by 17% in the 3 to 4 decades since then; which translates to approximately 4 cents a decade. As with men’s participation and child care and household chores, the gaps are narrowing, but substantial differences still exist.

Poverty

Poverty is still primarily a women’s issue in the United States and around the world. U.S. data show that 28% of all families headed by women live in poverty, a rate that is more than double that for families headed by single men (13%). Fewer than 5% of married couple households in the United States live in poverty (National Poverty Center, 2007). International studies show that of the 1.2 billion people worldwide living in abject poverty (less than \$1 a day), 70% are women (United Nations Millennium Project, 2007).

Corporate and Political Positions of Power and Leadership

Women are enjoying phenomenal advances and success in some areas. They now make up almost half of the workforce in the United States (47%; U.S. Department of Labor, 2009). Women are getting more education than ever before; they comprise the majority of undergraduate college enrollments in the United States and there are similar enrollment figures in all other industrialized countries in the world (57% in the United States; U.S. Census Bureau, 2007), although the percentages are close to equal or slightly favor men in Ivy League schools (Williams, 2010). Employment and college enrollment figures are within 10 percentage points of the U.S. data in most other industrialized countries in the world. The cumulative effect of this sizable difference in college graduation rates is very large. As might be expected from women’s higher educational achievement, there are increasingly more women than men in mid-level management positions, creating an overflowing “pipeline” ready for advancement to top-level executive positions.

Despite women’s success in education and mid-level management, few women make it to the “O” level—CEO, CFO, CIO, CTO in the corporate world or comparable top levels in noncorporate settings, such as the highest levels of political office, or top rungs of the academic ladder. In the United States, women hold more than 50% of all management and professional positions, but only 2% of Fortune 500, and 2% of the Fortune 1000 CEOs are women (CNNMoney.com, 2006, April 17). Comparable data from the Financial Times Stock Exchange 250 (FTSE 250; Singh & Vinnicombe, 2006) show that 2.8% of CEOs for the top 250 companies listed on the London Stock Exchange are women. It has been a half-century since the start of the Women’s

Movement, and women have only moved to the half-way mark in the corporate world and other organizations; most are stuck in middle management (Halpern & Cheung, 2008).

At the time of writing (January 2009), there are 192 countries in the United Nations. Eight have female presidents (Argentina, Chile, Finland, India, Ireland, Liberia, The Philippines, and San Marino) and eight have women prime ministers (Bangladesh, Germany, Haiti, Moldova, Mozambique, the Netherlands Antilles, Ukraine, and the Åland Islands). In the United States, Hillary Clinton's unsuccessful attempt to win the Democratic Party nomination for the U.S. Presidency in 2008 has been referred to as "eighteen million cracks in the glass ceiling," which is a reference to the number of votes she attained. Top-level leadership positions remain rare for women and even among current female politicians, with the possible exception of the German Chancellor Angela Merkel, none are as powerful as Britain's Margaret Thatcher, India's Indira Gandhi, or Israel's Golda Meir have been in the past.

THE BUGABOO OF BIOLOGICAL EXPLANATIONS

It was almost taboo to talk about gender difference in the brain.

—R. Mark George (brain researcher quoted in
Foote & Seibert, 1999, p. 68)

For many, it is frightening, and perhaps even un-American, to consider the possibility that even a small portion of the sex differences in cognitive abilities may be attributable to biological factors. This is probably because many people confuse biological contributions with the idea of an immutable or unavoidable destiny. Part of the fear of biologically based explanations of human sex differences in nonreproductive areas such as cognition is confusion about the term *biology*. Readers with expertise in the biological sciences may find this idea funny or strange, but for many people without expertise biology really does mean destiny, which is why biological hypotheses are greeted with suspicion and hostility. We are biological organisms, so at some level, whatever it is that makes us who we are is biological. But, this statement does not say much. Readers are urged to keep the biopsychosocial perspective in mind as they read through this book.

In 2005, Lawrence Summers, who was then president of Harvard University, "sparked an uproar" (Bombardieri, 2005) when he opined that one reason why women are underrepresented in science and math careers could be "innate differences" between women and men. Much has been written about what Summers said when he spoke at a luncheon meeting at the National Bureau of Economic Research (NBER). The uproar was in response to many of the points that Summers made, but it was fueled by his use of the word, "innate," which

means “inborn” or “not caused by experience.” If he had added that experiences alter our biology or that even if a trait is innate, it can be changed with experience, it is likely that the responses would have been less vitriolic. The words that we use are important and many people do not know that experience and biology have mutual effects on each other, a point that I make repeatedly throughout this book.

Summers was speaking at a conference that focused on the broad question of why women (still) comprise much fewer than 50% of the academic and other professional careers in the STEM fields (Science, Technology, Engineering, and Mathematics). Summers (2005) suggested that “There are three broad hypotheses about the sources of the very substantial disparities that this conference’s papers document and have been documented before with respect to the presence of women in high-end scientific professions.” The three hypotheses are (a) STEM fields require a high level of commitment to work, including very long hours, which women (more often than men) are unwilling to do because of family obligations; (b) women are discriminated against during hiring and promotions, a hypothesis that Summers largely rejected; and (c) there are many more men with very high aptitude for science and mathematics than women. Each of these hypotheses is discussed in several places throughout this book, but the general consensus about his remarks (Halpern et al., 2007a) is that there is good evidence that women have more family demands which interfere with careers that require 60 to 80 hours a week at work, so his first hypothesis is at least in part correct, although “unwilling to work long hours” may be a misleading way to consider these data. For many women, they are choosing instead to make sure that they spend sufficient time with their children so that their children will develop into secure and healthy adults and/or they may be choosing to support their husband’s career over their own (Ceci & Williams, 2010, 2011). Decisions are not by choice when the decision maker sees no other good options. Data presented in [Chapters 6 and 7](#) will show that there is evidence for discrimination against women in STEM fields, which contradicts Summers conclusion on this point. Finally, it was the third hypothesis that was the most controversial. There are some measures that show fewer women in the high ability “tails” of distributions, but the questions of whether these differences reflect “innate” differences or whether talented scientists really need genius levels of mathematical ability are far from settled.

The “Women Have Less” Fallacy

Not surprisingly (this is a book on sex differences), I find the reasons in favor of studying sex differences far more convincing than those against studying differences. Arguments against studying sex differences are often based on the implicit assumption that if the truth were known, women’s deficiencies would be revealed. This is simply not true. I call this implicit assumption the “women have less” fallacy because it is the mistaken belief that women will be found to

be less good than men in serious studies of cognitive abilities. Much of the research that is reviewed throughout this book documents multiple cognitive areas in which women, as a group, excel, as well as cognitive areas in which men, as a group, excel. There is no evidence for the inferiority of either women or men.

The critical importance of sex differences research was summed up well in a publication on understanding addictions, an area where sex differences are found on almost every measure of drug use. The authors concluded that, given the large differences in the extent to which males and females use drugs, type of drugs used, and physiological responses to drugs, “Conducting a sex/gender analysis of data is a matter of doing good science” (Wetherington, 2010).

Censorship in Science

“There is perhaps no field aspiring to be scientific where flagrant personal bias, logic martyred in the cause of supporting a prejudice, unfounded assertions, and even sentimental rot and drivel, have run riot to such an extent as here.

—Helen Thompson Wooley (1910, cited in Russett, 1989, p. 155)

The question that is being raised is whether there should be censorship in science, even self-imposed censorship, when results are likely to be misused. However, the danger inherent in censorship is far greater than the danger in publishing results that could be used for undesirable purposes. The answers provided in this book to the questions of sex differences are complex and contain many qualifiers. Readers who read only the chapters on biological hypotheses or only the chapters on psychosocial hypotheses without reading the final chapter that integrates both approaches will come away with different erroneous conclusions about the area. Quotations taken out of context can be used to support virtually any position because all sides of the issues have been considered and because it is possible to find research results to support almost any theory. The misrepresentation of biologically based explanations contributes to the chilly academic climate that women face in some advanced courses in the physical sciences and engineering and that men face in “nurturing” fields like nursing and social work. Keep in mind that results obtained from groups of males and females do not justify discrimination against individuals. Nor can we afford to confuse what has been with what could or should be. Sex differences that exist at the start of the 21st century American society do not necessarily exist in other societies, or in the American society of the future.

Sex Differences—Good and Bad

Beliefs about the desirability or utility of sex differences research often depend on the topic being investigated. For example, research that showed that

women's risk of heart attack rises after menopause or that women metabolize alcohol differently than men is usually hailed as beneficial because the knowledge can be used to improve the health of women. Similarly, Gilligan's (1982) book on sex-related differences in modes of thinking and reasoning about moral issues and the association of these modes with male and female "voices" has been embraced as a best-seller, even though the basic premise has not been supported with evidence. On the other hand, carefully executed research on sex-related differences in mathematical reasoning ability (e.g., Benbow, 1988) has generated hundreds of pages of vitriolic criticism (e.g., most of an entire issue of the journal *Behavioral and Brain Sciences*, 1988). Why are differences in moral reasoning that are based on minimal support hailed as beneficial and differences in mathematical reasoning dismissed and belittled as sexist (Tiger, 1988)? It is important that each reader attempt to keep an open mind in considering the research and the way in which it is interpreted. To do anything less is self-deceptive.

TERMINOLOGY

The terms we use to convey ideas reflect our own biases about the topic being discussed. I have argued elsewhere that different images and meanings are evoked depending on the choice of words that are selected to convey our thoughts (Halpern, 2003). Consider, for example, differences among the terms "senior citizen," "old man," and "golden ager." While, in some sense, these three terms can be considered synonyms, each conveys a somewhat different meaning. There is a reciprocal relationship between thought and language. The words that are used in the sex differences literature also influence how we think about the issues and the research results; therefore, I have decided to explain why I selected certain controversial terms.

Sex and Gender

Gender depolarization would . . . require a *psychological* revolution in our most personal sense of who and what we are as males and females, a profound alteration in our feelings about the meaning of our biological sex and its relation to our psyche and our sexuality.

—Sandra Lipsitz Bem (1993)

Some psychologists prefer to use the term "sex" only when they are referring to biological distinctions between males and females, while reserving the term "gender" to refer to the psychological features or attributes associated with the biological categories (e.g., Deaux, 1985; Unger, 1979, 1989). Gender used in this way refers to societal definitions of female and male traits and abilities (Goodnow, 1985). Levy (1989) articulated this distinction as follows: "The

term *sex* is used to refer to the grouping of people into the two distinct biologically defined groups of female and male. Gender, in turn, refers to the social categorizing of individuals based on social standards and ascriptions” (p. 306).

Pinker (2006b, para. 2) provided a clear summary of the problems with the terms “sex” and “gender”: “Part of it is a new prissiness—many people today are as squeamish about sexual dimorphism as the Victorians were about sex. But part of it is a limitation of the English language. The word ‘sex’ refers ambiguously to copulation and to sexual dimorphism, and it’s often important not to confuse them! The linguistic term ‘gender’ literally means ‘kind,’ as in the cognates ‘genus,’ ‘generic,’ and ‘genre’ . . . The basic problem is that we have three concepts to convey—intercourse, dimorphism, and social roles—and at best two words with which to convey them.” Other academics have decided, apparently by fiat, that “If you know that the difference is 100% biological it’s a sex difference. Everything else must be considered a gender difference” (Nobelius, 2004, para. 4). Pinker, who has an extensive background in psycholinguistics, noted that top-down prescriptions about lexical semantics are rarely obeyed.

I have decided to use the term “sex” to refer to both biological and psychosocial aspects of the differences between males and females because these two aspects of human existence are so closely coupled in our society. It is frequently difficult or impossible to decide if the differences that are found between females and males are due to biological (“sex”) differences or the psychosocial concomitants (“gender”) of biological sex. I cannot argue, on the one hand, that the distinction between environmental and biological variables is often artificial and that nature and nurture are inseparable and then, on the other hand, use different terms to refer to each class of variables. The term “gender” is more commonly used in studies and theories that focus exclusively on the social environment, so as a way of presenting that literature as accurately as possible with the language of the researchers, I use “gender” more frequently when discussing those studies. Most studies categorize females and males based on biology and not on adherence to sex or gender roles, so “sex” seems to be a more accurate description of how the studies are conducted.

The use of the term “sex” is not meant to imply that biological variables are more important than psychosocial ones or that the results being discussed are caused by differences in genes, hormones, sex glands, or genitals. The point that biological manifestations of sex are confounded with psychosocial variables is made repeatedly throughout this book. The use of different terms to label these two types of contributions to human existence seemed inappropriate in light of the biopsychosocial position that I have taken in several places throughout this book.

Language purists probably will agree with my choice of the word “sex” instead of “gender.” “Gender” was originally a grammatical term used in languages that make a distinction between feminine and masculine nouns. It is not related to maleness or femaleness even in these languages. Gender is also

sometimes used as a euphemism for the word “sex” because of the possible physical overtones implied by sex. Thus, for several reasons, gender seems to be an inappropriate label for the differences between females and males.

I also understand that language is a living phenomenon and that the meaning of words changes over time. Increasingly, gender is being used to refer to a host of variables that seem distinctly biological. Pearson (1996) wrote that the term “gender” is being used to refer to the molecular biology of plants, insects, flatworms, crustaceans, rodents, and even sphincter muscles. It is difficult to see how any of these referents are influenced by societal expectations of appropriate behaviors. The distinction between these two terms is becoming increasingly difficult to understand. Pearson cited this example from a scholarly paper, “In humans and other mammals, chromosomes determine gender. In other species, sex is controlled by temperature or even the social environment” (p. 330). Given the confusion about these two terms, readers may understand my decision to stick with the term “sex,” regardless of the purported cause of any differences. I also note here that some people are passionate about the difference between the terms “sex” and “gender.” It is ironic that the current editorial policy of the journal *Sex Roles* requires that authors use the term “gender.” It may be that over time, “gender” will encompass both biological and psychosocial aspects of being female or male. I use the “term” gender in several places, especially in [Chapters 6](#) and [7](#), which concern psychosocial aspects of cognitive development. But, in most places I use the term “sex,” for all of the reasons listed above.

Sex and Sex-Related

Other psychologists have urged that the term “sex-related” differences be used instead of “sex” differences in order to emphasize the fact that many of the differences that are reported are correlates of the biological distinctions between females and males and not necessarily due to biological differences (i.e., sex differences in cognitive abilities are not *caused* by the differences in female and male genitals; Sherman, 1978). Once again, the objective of this distinction is to separate biological and psychosocial determinants of between-sex differences. While I am aware of the consciousness-raising aspect of this distinction, I have decided to use the shorter term “sex differences” in recognition of the close relationship between biological and psychosocial variables, using the term “sex-related” only occasionally for emphasis. The preference for the term “sex differences” is not meant to imply a preference for biological explanations.

Abilities, Skills, and Performance

Because there is considerable disagreement about how well various theories can explain sex differences and whether sex differences could be eliminated

with appropriate instruction, other researchers have suggested that the term “abilities” should be replaced with other more neutral terms like “skills” or “performance” (Sherman, 1977). Once again, this distinction is based on the notion that the word “abilities” is suggestive of biological or immutable differences while the terms “skills” and “performance” are not. These three terms are used interchangeably throughout this book. The use of the term “abilities” is not meant to imply that the trait under discussion is either biologically determined or genetically linked. Abilities are developed in a social context, which includes opportunities for learning, cultural roles and values, the physical environment, and individual differences.

Females and Males, Boys and Girls, Women and Men

When a reference is made to children, I use the terms “girls and boys,” and when the reference is to adults, I use the terms “men and women.” (And yes, I try to alternate at random the order in which each sex is mentioned.) Many times, the reference applies to both children and adults or the age is unknown or irrelevant. In these instances, I use the terms “females and males.” I also use “males and females” when referring to nonhuman mammals—after all “girl and boy rats” just sounds silly, and as language-savvy readers already know, many frown on the use of “girl” or “boy” as an adjective.

Other Sex and Opposite Sex

Are females and males really opposites? They are both similar and dissimilar in multiple ways, but they are not opposite in the same way as day and night or sweet and sour. I prefer to use the phrase “other sex,” as a linguistic reminder that we are not different species from different planets, but two variations on being human, with similarities and differences.

Pronouns

Traditional English usage has required that the masculine pronoun “he” be used whenever the sex of the referent is unknown. The male bias in our language and particularly the use of the male pronoun to refer to either females or males is discussed more fully in [Chapter 5](#). Psycholinguistic research has shown that listeners tend to think of males when the male pronoun is used (Hamilton, 1988; MacKay, 1983; Merritt & Kok, 1995). It seems that, at least among western populations, the male is perceived as normative and the use of the pronoun “he” is literally assumed to refer to a male referent. For this reason and because of a personal dislike for this convention, I have rejected the exclusive use of the masculine pronoun and have alternated the use of female and

male pronouns throughout this book whenever the sex of the referent is unknown. Sex-neutral plural constructions (they) have also been used when they did not interfere with the topic being discussed, although recent research has shown that using “they” to refer to a singular referent whose sex is unknown can create the presumption that a male is being discussed (Foertsch & Gernsbacher, 1997).

SELECTIVE NATURE OF ALL REVIEWS

The purpose of this book is to provide a comprehensive review and synthesis of the research and theories that pertain to the questions of cognitive sex differences. Tens of thousands, maybe even hundreds of thousands, of journal articles and books have been written that address this topic. Different experimental methods have sometimes been used to answer the same questions, and the answers don’t always agree. Different results have frequently been obtained with the same tests, and similar results have been interpreted in different ways by different experimenters. Decisions had to be made continually as to which research is important and good. In an area as large as this one, only a subset of all of the available information can be presented. In addition, new knowledge is accumulating at an unprecedented rate. Thus, this review, like all reviews of the sex differences literature, is necessarily selective.

In deciding which research to include in this review, I followed a few basic guidelines. I decided to include research that is representative of many experiments when several similar investigations were reported on the same topic (e.g., many researchers have found that visuospatial skills can be learned), to include pivotal or “important” research that helped to clarify a theoretical position or to choose between two or more alternative interpretations of research, and to devote more space to the controversies than to the areas in which a consensus has been reached. I have also attempted to maintain a balanced view in this highly controversial area of psychology. This means that I will probably manage to offend almost every reader as I explore alternative explanations of research findings and the theories that guide the research. In those places where readers disagree with the information being presented, you may find yourself thinking about my own biases. Of course, I am no more free of bias than anyone else. I have attempted to stay close to the data and also to come to some conclusion based on what are often contradictory findings. I ask all readers to maintain a critical and open mind—to examine the evidence in support of positions that you may not favor and to apply the same scrutiny to conclusions that support your own point of view. I also believe that the answers we accept as true today will probably seem outdated and will sometimes be proven wrong in several years. There are no final answers, only the questions will endure.

You are about to read several hundred pages of text that will describe where sex differences are and are not found, prominent theories designed to explain cognitive sex differences, and research designed to test the theories. Some of what you read should challenge what you believe to be true, and at some point, every reader should expect to feel the discomfort of reading about findings that are contrary to your beliefs. Take a few minutes now and jot down your responses to some key questions? Do you believe that males are better at math than females (on average)? Do you believe that females are better at spelling or reading than males (on average)? Do you believe that females and males are equal on all cognitive tasks? If not, then using a number from 0 to 100, what proportion of any cognitive sex difference is due to biology, where 0 = none at all and 100 = all of it. Will you be able to consider information that runs counter to what you already believe to be true? Can you be an amiable skeptic—looking for evidence as fairly as you can?

ABOUT THIS BOOK

This introductory chapter is designed to set the stage for an examination of sex differences in cognitive abilities. Research methods and philosophies that determine how we answer the questions of cognitive sex differences are discussed in [Chapter 2](#). It is unusual to include a research methods chapter in a book on cognitive sex differences. It is included here in the belief that readers need to understand how the research questions were answered in order to understand the answers. Readers with a good background in experimental methods and statistics can skip or skim this chapter before going on in the book, but I hope that you will read it carefully because so much of our understanding of controversial topics depends on the quality of the research that was designed to answer difficult questions. [Chapter 3](#) examines the question of whether or not sex differences in cognitive abilities exist, and, if so, are they large enough to be theoretically or practically important? [Chapters 4](#) and [5](#) consider hypotheses concerning genetics, hormones, and brain–behavior relationships devised to explain cognitive sex differences, and [Chapters 6](#) and [7](#) consider learning, sex-role pressures, and cultural norm hypotheses. Competing and complementary research and theories are integrated in [Chapter 8](#), along with some closing thoughts for assimilating this large body of information.

Searching for Sex Differences in Cognitive Abilities

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Research is formalized curiosity. It is poking and prying with a purpose.
—Zora Neale Hurston (1942, p. 143)

The first step in our quest to understand if, where, and when sex differences in cognitive abilities exist is an examination of the experimental and statistical

procedures used to provide the answers. The kinds of questions we can ask about sex differences and the answers we get depend on the experimental and statistical methods used in research. The goal of this chapter is to consider the research issues that are important in evaluating the proliferating literature in the area of sex differences. Most of the issues are relevant to evaluating research claims in any area; others are unique to research about sex differences. The issues range from the basic assumptions underlying hypothesis testing to the methods used to integrate results across multiple studies. Readers with little or no background in statistical and research methods may have difficulty grasping some of the more technical explanations in this chapter; however, the general principles should be easily understandable to all readers. Reports of the actual research on sex differences will be presented in [Chapter 3](#), and research and theories designed to explain why differences exist are presented in [Chapters 4](#) through [7](#). As you will see in these chapters, not all of the researchers have employed the techniques that will be identified as desirable or necessary to reach a defensible or valid conclusion. Consumers of psychological research need to understand the strengths and weaknesses of different types of research and research practices. The validity of the conclusions from any study rests on the quality of the research from which they were generated.

WHY WE NEED RESEARCH

There is really no such thing as research. There is only search, more search, keep on searching.

—Elizabeth Bowering (1988, p. 95)

There are many areas of psychological inquiry where emotions run high. When this happens, research results that support a favored point of view are greeted with enthusiasm and those that do not are often dismissed as irrelevant, flawed, or biased, or simply ignored without any justification. In general, most people are far more distrustful and critical of research when it yields results that they do not like than those times when research results support conclusions that they believe to be true. Scarr (1997) made this point in her discussion of the public's response to a series of eight studies on the effect of working mothers on their children. Like many of the topics discussed in this book, most people have strong feelings about the effect of maternal employment on children. How can we know if a mother working outside the home harms (or helps) her children, holding other variables like parenting styles, involvement with children, and socioeconomic status constant? This is a difficult question to answer, and it is only through multiple large-scale studies with many different children and family situations that an answer about maternal employment can be obtained. None of the eight studies that Scarr reviewed found any evidence for the generally accepted conclusion that infants suffer negative consequences

when their mothers are employed outside the home. When Scarr appeared on National Public Radio to discuss these findings, her adversary made an emotional appeal in which she said that she felt the pain of the infants whose mothers went to work all day and that she would be their voice. The audience was apparently swayed by this eloquent and moving appeal; many agreed that the opinion of this single speaker was as valid as the results obtained from hundreds of infants in eight separate studies. Like many of the topics addressed in this book, the question of whether working mothers have negative effects on their young children is controversial and important. How can we find the best answer to important complex questions, where “best” is defined as the answer that most closely captures reality? Should we rely on anecdotes and “gut” feelings, or should we rely on the findings from multiple studies with careful controls?

Readers need to appreciate the critical importance of high quality research in answering complex questions, but they also need to be able to distinguish good research from shoddy research and valid conclusions that are supported by data from those that are not. Most readers are eager to “get to the heart” of the matter and read the conclusions that researchers have obtained, but the conclusions are only as good as the research that generated them, and for this reason our quest to understand when, where, why, how, and how much males and females differ and are similar begins with an overview of research and statistical methods.

A number of years ago, I had a conversation about the nature of sex differences with a member of an Eastern fundamentalist religion. There were no unresolved questions for him. One of the tenets of his religion was that women are best suited for home and child care, whereas, men are best suited for the intellectual and physical work needed to support a family. For him, any research on this question would have been superfluous as the answers were God given. Of course, not everyone shares his religious beliefs. I later learned that many members of his religious sect doubt his interpretation of the religious principles. For most of us, the many questions pertaining to sex differences require an empirical test; they are not taken on “faith.” An empirical test requires collecting information in as unbiased a manner as possible and then carefully scrutinizing it in accord with the rules of evidence to determine what, if any, conclusions can be drawn. Research methods provide the tools for understanding the relationships among variables, in this case, among sex and the cognitive or intellectual abilities. The experimental method is a potentially objective method that allows researchers to confirm or disconfirm their hypotheses or beliefs. I have described the experimental method as “potentially objective” because, as explained in [Chapter 1](#), it is impossible for research ever to be totally objective. The very questions in which researchers are interested and the way in which they construct hypotheses and decide what variables to measure are contaminated by their beliefs, prejudices, and societal values. We all view controversial issues from

our own point of view, so it should be no surprise that we often do not “see” the same issues or pose the same problems. The hostile and politically charged climate surrounding sex differences research has called into question the possibility of ever obtaining bias-free research. Although many people are distrustful of research results and, as discussed in [Chapter 1](#), research is certainly not value-free, the scientific method is still the most objective, unbiased, and systematic approach available for finding answers to questions. As a way of knowing, the scientific method is much less biased than any alternative method for understanding the relationship among variables in the social or physical world.

There are several different ways of conducting research, each of which has advantages and disadvantages. Let’s consider how various research methods can influence the type of information they yield.

TYPES OF RESEARCH INVESTIGATIONS

The best method for collecting data will depend on the research questions. Although we expect to find converging evidence for conclusions using data generated with different methods, sometimes the method influences the results and conclusions in unexpected ways.

Anecdotal Evidence

Most people have strong beliefs about sex differences. Stop and ask almost anyone about sex differences with regard to a specific ability, math for example, and you are likely to get an answer like this one: “Of course, boys are better than girls in math. Both my sons did well in math, but my daughter just hated it.” (Notice that this answer switched from performance in mathematics to attitudes toward mathematics.) Or, you might get an answer like this one: “Personally, I think that women are better at math than men. My husband always depends on me to balance the checkbook.” There is a tendency for people to rely on and to prefer personal anecdotal answers to questions instead of general ones derived from large samples. This preference reflects a well-documented bias in favor of using one’s own experiences in understanding human behavior (Dawes, 1994; Halpern, 2003). Many people find a single anecdotal example more persuasive than a series of well-documented research findings. The tendency to rely on a single example to formulate general laws about human behavior is called the “I know a person who” phenomenon. This is a strong, pervasive, and seriously flawed way of understanding behavior. Even researchers can be swayed by the power of anecdote. Its pervasive effects are not limited to nonscientists. Unfortunately, research statistics are faceless and bland; no match for the personally relevant experience of each individual.

If you doubt the powerful influence of single examples, try this mini-experiment:

Tell several people that the recent winner of a prestigious mathematics contest (make up a serious sounding name for the competition, like the Mathematics Scholars Program) was a 10th grade girl. Tell them also that numerous researchers have found that high school boys outscore high school girls on most standardized tests of mathematical ability. Now, ask them if the fact that a female won a prestigious contest in mathematics weakens the conclusions from the research studies. You'll find that many people, especially those who are not familiar with the research method, are willing to discount the results from numerous studies because of a single example that is contrary to the research results.

There are many problems with anecdotal answers or conclusions that are based on a single example. First, our own experiences and those of our friends and family may not be typical of people in general. We may be generalizing to all or most males and females from atypical observations. Second, they are biased in predictable ways. Our memories are fallible and may be influenced by our beliefs and expectations. There is a wealth of evidence in the social psychological literature that shows that stereotypes are difficult to disconfirm because we select and remember information from our environment that is consistent with our beliefs (e.g., Halpern, 1985). Third, anecdotal evidence lacks precision. You might remember that your brother got higher grades in mathematics than you did, but you might not remember how much higher. Most importantly, such evidence can rarely be used to determine cause. Did your sister perform poorly because she lacked ability or was she discouraged from performing well? Despite the typical reliance upon personal experience to formulate general laws of human behavior, only systematic investigations of large samples of data that are representative of the population we want to know about (in this case, all men and all women) can provide answers to questions relating to sex differences.

Carefully controlled research is also needed because of the human tendency to reject results that are not in accord with our belief biases. Consider a letter to the editor that appeared in *The Chronicle of Higher Education*, which is a leading publication for articles related to education. The letter was written by an assistant professor of physics in response to an article about sex differences in spatial skills. Asaro (1990, p. B4) wrote that the notion that men have better spatial skills than women is "another of the erroneous stereotypes." You should be wondering "What is the strength and nature of the evidence that supports Asaro's conclusion?" The only evidence given by Asaro was that she observed no sex-related discrepancies in spatial abilities in her personal experience. An "alarm" should go off in your head every time someone offers a conclusion about all women and men based solely on his or her personal experience. Anecdotes and case studies, which are based on one or a few individuals, can be a rich source of ideas for future, better controlled research, but without the

strength of well-designed studies, they are more likely to reflect personal biases and predilections than reliable findings that can be generalized to the broader population.

Surveys

Another weak type of evidence for understanding the nature of cognitive sex differences comes from survey data, although they may be useful when studying other topics, such as how people feel about a topic or group of people. Surveys can take many forms. Sometimes, surveys ask what skilled activities you perform well or poorly. If more women than men were to report that they write poetry well, would you be willing to consider this finding as support for the notion that women have better poetry or language skills than men? I hope not because differences in self-reports may not reflect differences in actual abilities. The unreliability of self-report data is well established across many fields of study. It is possible that more women report that they write poetry well because it is a more socially acceptable trait for women. It is possible that comparable numbers of men also write poetry equally well, but they are unwilling to admit it.

Sometimes, surveys involve simple head counts of the number of women and men in a selected category. For example, virtually every such survey finds that there are many more men than women in math-related occupations such as engineering and physics. Head count surveys may provide interesting information about “how many” and “how much,” but they can never tell us *why* each sex has disproportionate representation in certain occupations. Are there more male mathematicians because men have greater mathematical ability or only because it is more difficult in our society for women to gain access to these occupations? Although anecdotes and surveys may seem intuitively appealing, they are limited in the type of research question for which they can provide answers.

On the other hand, like anecdotes, one advantage of surveys is that the results can be used to suggest topics for future research. For example, the social psychologist Jacquelynne Eccles (2008) has spent decades answering questions about people’s expectations for success and the extent to which they value achievement in different academic domains. Like many other researchers, she used surveys as a springboard for more rigorous research. Her model of the way expectancies and values affect achievement is discussed in [Chapter 6](#).

Correlational Approaches With Nonrandom Assignment of Subjects

In a correlational approach, the relationship between two or more variables is examined. Suppose, for example, that you read a newspaper report on the relationship between marijuana use and scholastic aptitude that argued that

marijuana has a deleterious effect on scholastic aptitude based on the finding that SAT scores declined during the years that marijuana was in heaviest use, and SAT scores increased when marijuana use declined. This argument is based on the negative relationship between SAT scores and marijuana use; when marijuana use increased, SAT scores declined and when marijuana use decreased, SAT scores increased. Let's suppose that the data in support of this claim are correct. Can you find anything wrong with this line of reasoning? What is missing is the *causal link*. It is incorrect to infer that marijuana use was responsible for the rise and fall in SAT scores. It is also possible that changes in SAT scores caused the changes in marijuana use. Maybe when students perform poorly on the SAT they smoke more marijuana, and as their scores improve they smoke less marijuana. In this hypothetical example, it is possible that a third variable that was not known to the researcher could be causing changes in both marijuana use and SAT scores. For example, changes in the economy could be responsible for the increase in marijuana use and the decrease in SAT scores. (Perhaps when the economy is tight, students take school more seriously and have less money to spend on drugs, with the reverse occurring in a booming economy.)

Even if we could link marijuana use directly to changes in SAT scores, we would still not know if changes in marijuana use caused the changes in SAT scores or whether changes in SAT scores caused the changes in marijuana use. The problem being raised here is commonly known as "causal arrow ambiguity." The coincidence of changes in two variables does not provide support for the notion that one variable is responsible for the concomitant changes in the second variable. In order to determine if marijuana smoking *caused* changes in SAT scores, students would have to be assigned at random either to smoke or not to smoke marijuana for a predetermined period of time. If researchers used this experimental design, it would be a "true" experiment, which is discussed in more detail later in this chapter. If we found that the group who smoked marijuana scored, on average, significantly lower on the SAT than the group that didn't smoke marijuana, then we could conclude that marijuana smoking is deleterious to SAT performance. Unless subjects are randomly assigned to conditions, it is likely that students who voluntarily smoke marijuana differ in many ways from those who do not (e.g., differences in socioeconomic status, attitudes toward illegal drugs, parental control, etc.). It is possible that any or all of the other differences are responsible for the decline and subsequent increase in SAT scores.

Most of the research on sex differences does not employ the random assignment of subjects to conditions because it usually is not possible to intervene in people's lives and change their life experiences. Of course, we cannot assign people to be male or female, so you can never know what life might have been like if you had been born the other sex. Sex differences research often involves studying males and females "the way they are," that is, without experimental manipulations. For example, suppose an investigator reports that the ability to

visualize objects in space is positively correlated with the amount of male hormones present during prenatal development. A positive correlation in this example means that in general, having more “male” hormones prenatally is associated with being better at visualizing objects. Such a result constitutes only weak evidence for the hypothesis that the prenatal concentration of male hormones causes good visual spatial ability because of the problem of some other unknown variables that might be affecting both the level of hormones and visual spatial ability. It is possible that many children with high levels of prenatal male hormones also had different home environments or different socioeconomic backgrounds than children with low levels of prenatal male hormones. Or, more likely, males not only have prenatal “male” hormones, but also have life experiences that encourage the development of spatial skills. How can we determine if it is the life experiences or the prenatal hormones or both or some third unidentified variable that is responsible for the good spatial ability? Alternative explanations are possible whenever subjects are not randomly assigned to experimental conditions. All research based on naturally occurring events without experimental manipulations is necessarily confounded (i.e., more than one variable changes at the same time, in this case, the biological determinants of an individual’s sex varies along with sex-related life experiences) and cannot provide causal information.

Correlational data with nonrandom assignment can provide a stronger case for causation if the results are in accord with a highly plausible theory and when other sorts of data provide converging evidence for the relationship being studied. Suppose, for example, there is reason to believe that if male hormones are high during fetal development, then the neurons in the area of the brain specialized for vision show a more complex pattern of dendritic growth with more interconnections with other neurons. If this theory were true, then the finding that high concentrations of prenatal male hormones are positively correlated with the ability to visualize spatial objects would provide corroborative evidence that these hormones underlie spatial visualization abilities. This is a totally fictitious theory that I devised to make the point that research conducted with nonrandom assignment of subjects in conjunction with a strong theory provides better evidence for causation than the research alone. In this case, data involving nonrandom assignment of subjects would serve to corroborate other empirical sources of support for the theory. In fact, any report of sex differences without a theoretical underpinning to explain why the sex differences occurred should be viewed with skepticism. Like survey results, serendipitous findings can be valuable if they are used as an impetus for additional research and if they can be incorporated in a testable theory.

All research results are necessarily probabilistic, which means that sometimes sex differences will occur in experiments by chance. If all of the human research conducted included a test for sex differences, many spurious reports of sex differences would clutter the literature. It is prudent to consider any atheoretical reports of sex differences as chance findings until they are

replicated and cast in a theoretical framework. In addition, good research will begin with a theory, which is an explanation for “why” something happened. Some examples of theories are: “Boys develop superior spatial skills because they play with spatial toys” and “Women are better at recognizing faces because they do most of the infant and child care, which causes them to attend more carefully to facial expressions.” A good theory is an organized set of principles that allows for the creation of new predictions. A hypothesis is a statement about relationships that can be tested with research. For example, hypotheses that follow from the two sample theories are: “Girls who are given spatial toys to play with will perform better on spatial tests than girls who do not have spatial toys” and “Men who are the primary caretakers for infants will be better at recognizing faces than men who are not primary caretakers for infants.” It is important that the hypothesis be clearly stated before the research is undertaken because post hoc (after the fact) explanations for data are no substitute for beginning research with a clear predication of the relationships that will be found.

If correlational data can be used to support a “highly plausible theory,” the problem remains of determining what makes a theory “highly plausible.” The mere existence of a theory is not sufficient. A theory needs to be supported empirically with research conducted in multiple settings, using different samples of subjects, and different measurement techniques before it gains the status of *highly plausible*. It also needs to fit within an existing framework of facts. There are many theories about sex differences in male and female brains. Yet, these theories are surprisingly mute on the mechanisms that underlie these differences. Like the proverbial chain, a theoretical network is only as strong as its weakest link. A strong theory can explain and predict the causes, correlates, and consequences of cognitive sex differences.

Observational Techniques

With observational techniques, researchers literally “look” at behaviors, usually in “real world” situations. Suppose that you were interested in knowing if young girls really differ from young boys with respect to aggression. You could observe the playground behavior of young children, keeping a tally of the number of aggressive acts committed by boys and girls. One of the advantages of this technique is that you would be actually observing *real* behavior rather than relying on some secondary technique like asking girls and boys about how aggressive they are. However, this technique has many of the same problems associated with it as noted in previous sections. Even if you found that boys (or girls) committed more aggressive acts, observation can never provide an answer as to why these sex differences occurred. There are also other drawbacks to this technique. Observations are never really objective because we tend to see what we expect to see. If a girl pushes a child on the playground, it may appear less aggressive to an experimenter than when the

same push is done by a boy. It is also likely that children will behave differently if they know that they are being observed. Thus, by observing the behavior, the researcher may actually have changed it. The choice of where to observe behavior also becomes important. A researcher may find sex differences on the playground, but not in the classroom or on the soccer field because much of our behavior is context-dependent.

There is also the possibility that aggression looks different when it is exhibited by boys and girls. Suppose that girls show their aggression with the use of mean gossip that ostracizes the object of their aggression and boys show aggression with physical assaults (e.g., Smith, White, & Moracco, 2009). If this theory is correct, and there is ample research to suggest that it is, then girls and boys might be equally aggressive, but researchers would never know it if all they measured was acts of physical aggression.

True Experiments and Quasi-Experiments

Most researchers consider the experiment as the method of choice for determining cause. In a “true” experiment, the researcher has greater control over the variables because subjects are assigned at random to experimental and control groups. Consider the hypothetical example (cited earlier) of the relationship between prenatal hormones and spatial visualization ability. In a true experiment, the researcher would select the subjects, in this case female and male fetuses, assign them at random to either high-hormone or low-hormone conditions by administering drugs to their mothers, measure their spatial visualization abilities later in life, and examine the neural structures in the parts of the brain that are presumably affected by the hormones. The underlying assumption is that large groups of subjects selected at random will be more or less equivalent with respect to the variable of interest, in this case spatial visualization ability. If we systematically vary only one aspect of their lives (prenatal hormones) so that overall the two or more groups differ only in this way, we can attribute any major differences between groups to this “treatment.” Presumably, there would be rich and poor, smart and dull, tall and short children of each sex in each group, but the only consistent between-group difference would be the nature of the variable the researcher has manipulated.

Very few “true” experiments with humans are ever conducted in the area of sex differences. Obviously, we cannot vary the concentration of selected hormones that certain fetuses will be exposed to before birth. Such interventions would be unethical and unconscionable. Instead, we must take people “as they come” and lose the control that is needed to understand causal links. A paradox in sex differences research is that the major variable of interest—being female or male—is never assigned at random. If we find that women perform a task, on average, better or worse than men, we still cannot answer the question, “why?” There are many variables that covary (or go along with)

biological indicators of sex in our society, such as hormone concentrations, social expectations, power, status, childbirth experiences, and learning histories to name a few. Given that so many variables are confounded with sex and that sex is never randomly assigned, causal attributions for any between-sex difference will be difficult to support. This is an important point because all sex differences research with humans is basically correlational in nature; true experiments are conducted only with nonhuman mammals and other animals. Researchers can never be certain if any between-sex differences are due to the biological aspects of sex, psychosocial concomitants of sex, the interaction between them, or some unidentified factor. But, with a variety of methods, including true experiments with nonhuman mammals and other types of replications, we can be fairly confident in our conclusions. We never have “proof” in an experimental science, but we can accumulate evidence in favor of a conclusion, and a greater body of evidence can give us more confidence in our conclusions.

Because subjects can never be assigned at random in sex differences research, a somewhat less stringent procedure for examining cause is sometimes used. Quasi-experiments, like true experiments, involve some sort of experimental manipulation, but do not randomly assign subjects to groups. An example of a quasi-experiment might be to provide an educational or counseling program to a group of females who score poorly on mathematics tests in order to reduce “math anxiety.” In interpreting the results, the experimenters would determine if the females scored significantly higher on the test of mathematics ability after they received counseling to reduce their math anxiety. Research of this sort must also include a control group, in this case a group of females who score low in mathematics but do not receive the counseling, so that meaningful comparisons can be made. An experimental design of this sort involves a manipulation (the counseling to reduce math anxiety). But because the participants were identified as females with low scores in mathematics, it would be inappropriate to generalize beyond this group or make any conclusions about females or males in general. Quasi-experimental research designs allow the researcher to examine causality (math anxiety possibly caused the low mathematics scores), but does not permit strong causal statements because people are not assigned randomly to different groups.

The fact that biological sex creates very different environments for males and females from the moment of birth means that differences in biological sex are always associated with different environmental experiences. Distinguishing whether nature or nurture is the more probable cause of sex differences is so difficult because of the confounding of nature and nurture. This is particularly germane to the controversies surrounding cognitive abilities. I return to this theme in several places throughout this book because it is critical in understanding the etiology or origin of sex differences.

Comparisons of Research Methods

Hendricks, Marvel, and Barrington (1990) suggested a “methodological cube” for summarizing the differences among research designs. Their cube is shown in Figure 2.1. As you can see in this figure, descriptive, correlational, quasi-experimental, and true experimental designs differ in the kind of information they provide. Research designs can also vary as a function of setting (laboratory or field) and the way the data are collected (observation or self-report). These three dimensions form the axes or edges of the cube. As you read about the research that is described in the following chapters, keep these variables in mind because they determine the kinds of inferences that we can make from the data.

Factor Analytic Approaches

A common method of studying human cognitive or intellectual abilities has been the factor analytic approach (e.g., Thurstone & Thurstone, 1941). The underlying rationale for this approach is that cognition is not a single homogeneous concept. Most psychologists believe that there are several cognitive abilities and that individuals can be skilled or unskilled in one, some, or all of them. Although there is an intense debate among psychologists over the

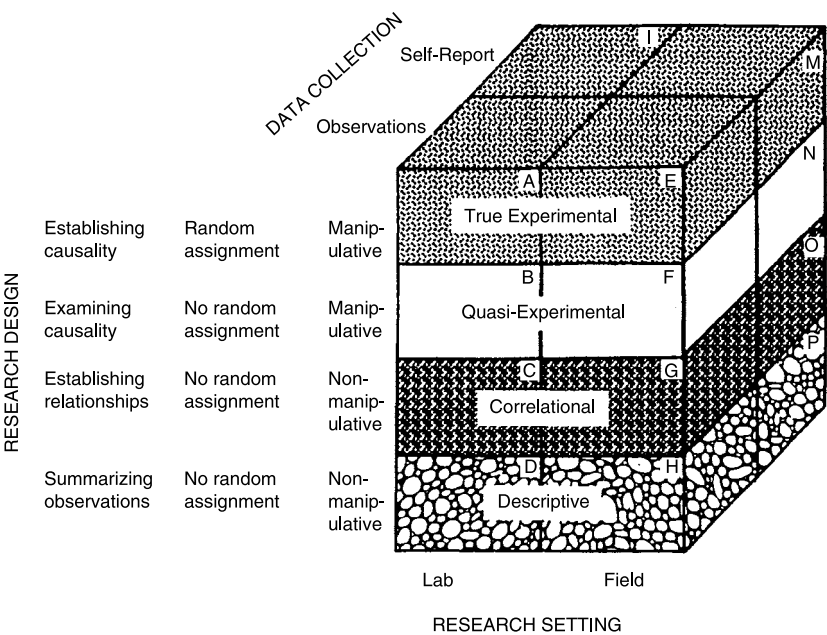


Figure 2.1 Methodological cube of group research methods. From Hendricks, Marvel, and Barrington (1990). Reprinted with permission of Taylor & Francis.

question of whether these abilities are all related to a single intelligence factor, as discussed in [Chapter 1](#), one of the most common theoretical distinctions is between verbal and spatial abilities.

One way to test hypotheses about sex differences in factor structures, which is the way variables form meaningful groups, is to give a large number of women and men several tests of verbal abilities (e.g., vocabulary comprehension, verbal analogies) and spatial abilities (e.g., using maps, solving jigsaw puzzles). If these four tests are really measures of two different abilities, then through the statistical technique known as factor analysis, two factors or underlying dimensions will result from the data analysis. The first factor, which we believe represents verbal ability, will be created from the vocabulary comprehension and verbal analogies test scores, and the second factor, which we believe represents spatial ability, will be created from the using maps and solving jigsaw puzzles test scores. (The actual mathematical principles and procedures involved are not germane to the purpose of this discussion and therefore are not described. The interested reader is referred to Tabachnick and Fidell, 2007 for a lucid discussion.) If we obtained the same two factors for both our sample of women and our sample of men, then we would conclude that women's and men's cognitive abilities have similar factor analytic structures. Suppose, by contrast, that we found that only one factor emerged for our sample of women. This would mean that these four tests had a single underlying dimension for women. (Another way of thinking about this hypothetical result is that the four tests were all measuring the same unitary construct.) If our sample of men yielded two factors from these tests, and our sample of women yielded only one factor, then we would conclude that there are sex differences in cognitive processes.

Here is an example that used factor analysis as a way to study cognitive sex differences. Researchers gave women and men a battery of 42 different cognitive tests (Johnson & Bouchard, 2007a; Johnson et al., 2007). They wanted to see if performance on these 42 separate tests could be made more meaningful by reducing the number to a few basic constructs that these tests measured. To get an understanding of what they did, look carefully at [Figure 2.2](#) (Johnson et al., 2007). Start with the information in the right-hand column. You will see that the researchers used 6 tests to measure verbal ability, 11 to measure scholastic ability, and so on. The scores on these eight different types of tests were then analyzed with factor analysis. This statistical procedure showed three main groupings or factors, which they labeled verbal, perceptual, and image rotation. The researchers then determined that these three factors were also related to each other, which is the idea of a single measure of intelligence or *g*. By breaking intelligence into three broad categories, the researchers were able to examine possible sex differences in these three categories of cognitive abilities. Although much more will be said about these constructs, in general, the results supported the idea that women, on average, excelled on the verbal tests and men on the image rotation tests. Women also showed generally better

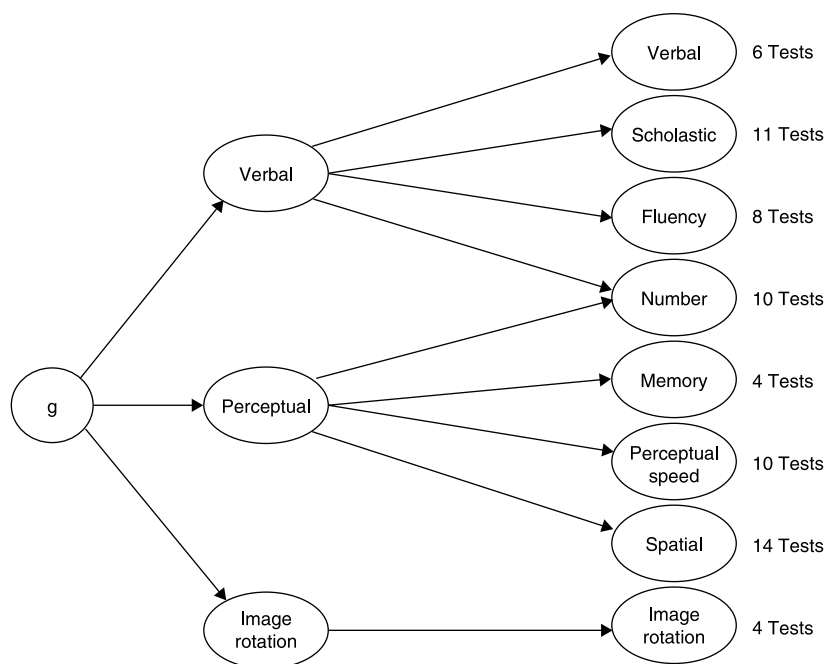


Figure 2.2 An example of a factor analytic approach to studying cognitive sex differences. From Johnson and Bouchard (2007a). Copyright © 2007, with permission from Elsevier.

memory than the men, so they also excelled on the perceptual construct that included memory (Johnson et al., 2007).

VALIDITY, FAIRNESS, AND BIAS

Many of the studies that will be reviewed in later chapters are based on comparisons of average test scores for males and females. Throughout our lives, but especially during the school years, everyone takes many tests. Some of these tests are *high stakes*, that is they are the basis for decisions that affect lives—who will get into college or professional school, graduate, or get a job or a promotion. For most of the *high stakes* tests, there are multiple group differences, or *on average* differences—differences that vary as a function of sex, racial or ethnic group, socioeconomic status, major in college, and geographic region, among others (Willingham & Cole, 1997). Does the fact that there are group differences mean that the tests are biased? Increasingly, this question is being asked in the courts and in state and federal legislatures.

The stakes are high, and there are *winners* and *losers* in this sorting process, so it is not surprising that many of those involved are highly critical of society's reliance on any standardized testing that shows group differences.

Questions about bias and its flip-side, fairness, depend on how these terms are defined and how test scores are used. "Fairness" is both a statistical concept and a matter of societal values, and frequently these two types of fairness are at odds with each other. In general, tests are used for three purposes: to assess past learning, to measure learning gains after an intervention such as a college course, and to predict the future. Standardized college entrance examinations, such as the SATs and American College Test (ACT), measure the level of ability that has been developed up to the time the test is taken, and based on this index of prior learning, predictions are made about probable success in future learning tasks. This is one type of validity, called predictive validity. For statisticians, psychometricians (people who specialize in the science of measurement, often in psychological constructs like intelligence or personality), and other sorts of testing experts, a measure is fair or free from bias if it predicts success on some variable equally well for people from different groups (Halpern, 2002). Thus, if a test was designed to predict success in college, and success in college was measured by grade point average, a fair test would predict college grade point average with the same degree of accuracy for all groups. Based on this definition, we would conclude that such a test is fair or unbiased because it has approximately equal predictive validity for all groups.

Although fairness and bias are abstract statistical concepts, in reality they have a very different meaning to those who are not testing experts. For the general public, bias and fairness are tied to concrete circumstances. In general, selection tests seem unfair to those who are not admitted to a desirable program or denied a good job and seem fair to those who "get in." Studies have shown that judgments about the fairness of affirmative action policies vary depending on whether one's own group was going to obtain the benefit of the affirmative action (Graves & Powell, 1994). To understand just how difficult issues of fairness in testing can be, consider the U.S. Supreme Court (2009) ruling about a test that was used to promote firefighters in New Haven, Connecticut. All of the lower courts ruled that New Haven had acted appropriately when it threw out the results of the test because very few of the firefighters from racial and ethnic minority groups scored well on it. The Supreme Court ruled that by throwing out the test results the city of New Haven was discriminating against the White firefighters who scored well and would have been promoted based on the test results. The Court ruled that a test can have "disparate impact," which means that some groups score better than others on the test, but that the test is not necessarily biased. Perceptions about the fairness of selection tests often lie in the special interests of the beholder. For this reason, Messick (1995) urged that we consider the social consequences of a test along with other validity and fairness-related issues. Some readers will consider the Court ruling to be "fair," and others will consider it to be unfair. It is possible to have

group differences on a test that might be due to differences in the quality of learning opportunities or some other variable and not necessarily because the test is biased. In thinking about your own feelings, are you also able to understand that reasonable people can disagree over concepts of fairness?

UNDERSTANDING RESEARCH RESULTS

Scientific inquiry is a voyage of discovery toward a horizon, beyond which yet another horizon beckons.

—David G. Myers (1998, p. 29)

Many of the questions pertaining to sex differences and similarities relate to the general principles of the scientific method. A firm foundation in the underlying assumptions of and rules for scientific inquiry is a necessary prerequisite for a critical analysis of the research literature.

The Logic of Hypothesis Testing

A researcher searching for sex differences is really considering two mutually exclusive hypotheses. The first hypothesis is that there are no differences in the overall population between males and females with respect to the variable being studied and, therefore, any differences found between the two samples are due to random error or chance differences in the samples selected. This hypothesis is called the null hypothesis. The competing or alternative hypothesis is that there really are differences in the population between women and men and these differences are reflected in the sample of males and females that is being studied. The researcher uses statistical tests to decide if any between-group differences are likely to have occurred by chance. If the tests show that the differences between the samples of women and men probably were not due to chance factors, then the experimenter can reject the null hypothesis and “accept” the alternative hypothesis. Thus, we formulate conclusions in a somewhat backward fashion. We conclude that the alternative hypothesis is probably true by deciding that the null hypothesis is probably false. In hypothesis testing, demonstrations of sex differences rely on a clear-cut set of procedures which involve deciding that the null hypothesis (the one that states that there are no sex differences) is probably wrong, and therefore the competing hypothesis that sex differences exist is tentatively considered to be more correct.

The Problem of Null Results

Proving the null is centrally important to the development of theory.

—Charles R. Gallistel (2009)

What about failures to reject the null hypothesis? Any serious researcher in the field of sex differences is also concerned about similarities. How can she or he conclude that there are no sex differences? This is a much more difficult problem and one that is particularly troublesome for research in the area of sex differences. Unfortunately, we can never accept the null hypothesis. The best we can do is fail to reject it. The strongest statements that can be made from failures to reject the null hypothesis are that the data do not support the notion that sex differences exist. We cannot conclude that differences do not exist. There are two reasons why failures to find differences cannot lead to the conclusion that there are no differences: statistical (the alternative hypothesis is not precise enough to permit the computation of the probabilities needed to reject it), and logical. (A more detailed explanation of the statistical reasons is beyond the scope of this book. Readers who have not had a course in statistics or experimental methods will have to take it on faith that there are mathematical reasons why claims of no sex differences cannot be accepted statistically, at least not with the usual methods for testing hypotheses. Interested readers are referred to Wagenmakers, 2007.)

Consider a simple example, which should help to clarify this point. Suppose you formulate the hypothesis that girls are better than boys at spelling. In this case, the null hypothesis predicts that there is no difference in spelling ability between boys and girls. To test your hypothesis, you collect the spelling test papers from a third grade class and tally the number of words spelled correctly, on average, by the girls and boys in this class on this test. You would then conduct a statistical test to determine if the results you obtained are unlikely to have happened by chance. Usually researchers set a chance criterion at 5%. If the results would occur by chance less than 5% of the time when the null hypothesis was true (i.e., there really was no difference in the spelling skills of the boys and girls), then you would reject the null hypothesis and conclude that something other than chance was happening and there really are differences between the sexes in their ability to spell correctly.

What if the statistical test showed that you could not reject the null hypothesis? You could not then conclude that there really are no differences in spelling ability between the boys and girls. It could be that sex differences do not show up on spelling tests when the words were just studied, but would show up on other measures of spelling, or that the test was too easy or too hard to show differences (almost everyone got all of the words right or wrong so there was so little variability). The list of possible reasons why you failed to find sex differences is virtually endless. All that you can conclude is that you “failed to reject the null hypothesis” *not* that the null hypothesis is true. The scientific method is one reason why researchers focus more on sex differences than between-sex similarities.

It may seem that studies that don’t show sex differences should “cancel” studies that show sex differences. Assuming the studies were well conducted, those that find sex differences (positive studies) carry more weight than

those that do not (negative studies) because it is always possible that the negative studies were not sensitive enough to detect a difference. Too few subjects, a poor test, plain old sloppy research, or numerous other problems can lead to false negatives. Thus, in the logic of hypothesis testing, we can never directly prove a null hypothesis. We can only disprove or reject the null hypothesis (the one that states that there are no sex differences) which, in turn, allows us to accept a mutually exclusive alternative hypothesis (the one that states that there are sex differences). (See Rozeboom, 1960, for a classic discussion about the failure to reject the null hypothesis.)

Consider an experiment conducted by Seth-Smith, Ashton, and McFarland (1989) in which they reported that there are no sex-related differences in brain organization for verbal functioning. Although their study was well designed, they used only 10 college-aged men and 10 college-aged women. Their sample size was too small and too restrictive (college students only) to conclude that there are no sex differences in brain organization. The strongest statement that can be made from studies like this one is that the researchers failed to find differences with the specific sample and experimental procedures that were used. We cannot use these results to conclude that there are no differences. The logic of hypothesis testing is the backbone of the experimental method, and it does not permit a similarities conclusion.

There are some experimental and data analytic techniques that allow researchers to investigate similarities. Murphy (1990) suggested that if the focus of a research program is similarities, the researcher could specify a range of outcomes that would be consistent with the hypothesis that there are no differences. For example, if I wanted to show that there are no sex differences in intelligence, I could give a large sample of women and men an intelligence test. I would have to specify *a priori* (before the data are collected) that if the average difference between the sample of females and males is less than two points, this result would be consistent with the hypothesis that there are no sex differences. It is also important to consider the *size* of the difference, a very important topic that is discussed in more detail in a later section in this chapter. There are also measures of concordance or similarity that can be used to provide evidence of similarity (e.g., correlations, Cronbach alphas, and factor loadings).

Most sex differences researchers are as interested in discovering similarities between females and males as they are in differences, yet, it is axiomatic that they can never definitively conclude that differences do not exist, at least with the standard practice of null hypothesis testing. Recently, Gallistel (2009) has suggested a statistical technique for deciding if the null hypothesis is likely to be true. The underlying idea involves computing the odds that two groups really are the same and then using statistical techniques to decide if the data favor the null hypothesis. The details of his suggestions require an advanced understanding of statistics, and they are likely to be controversial

among statisticians, but if his suggestions become widely used, then we may see more researchers in the future concluding that the null hypothesis is supported.

Rosenthal and Rubin (1985) have distinguished between the use of the experimental method to establish facts versus its use to summarize research. They argue that it is virtually impossible to establish facts with any single study. In their view, a research report is publishable “if it contributes important evidence on an important scientific question” (p. 527). I believe that their point is especially relevant to research into the nature of sex differences. Although it may not be possible to *prove* that sex differences in a particular area do not exist because of the strict logic of hypothesis testing, it is important to know if large numbers of researchers fail to find sex differences. If, for example, we knew that 95 out of every 100 investigations of mathematical sex differences failed to find differences, this information would certainly cause us to alter our conclusions about this area.

What about the studies that report differences? If half of them find that females score higher and half find that males score higher, it seems likely that experiments that report differences are “statistical errors.” That is, they may have occurred “just by chance.” On the other hand, suppose that all of the studies that report differences find that one sex is consistently scoring higher on one type of mathematical test. This sort of evidence would suggest that the positive results are not occurring by chance and that differences may be specific to one type of test—e.g., geometry—or to one subpopulation—e.g., children.

The Debate Over Null Hypothesis Significance Testing

In recent years, numerous statisticians and researchers have been engaged in a debate over the underlying principles of “null hypothesis significance testing” (Balluerka, Gomez, & Hidalgo, 2005; Rosnow & Rosenthal, 1996). Part of the debate is over the idea of a null hypothesis—whether it is ever possible to have zero differences between two groups (e.g., if we measured the spelling ability of every girl and boy in the world could it ever be possible that there would be absolutely NO difference at all between these two groups?) and, part of the debate concerns the misuse and misunderstanding of hypothesis testing. Even if a researcher concluded that the results she obtained are “statistically significant” (not likely to have occurred by chance if the null hypothesis were true), this does not mean that the difference between the girls and boys was large enough to be important or meaningful. For example, in a large sample, 2 percentage points may be statistically significant, but is it a big enough difference to matter in the “real world?” I will return to this point in [Chapter 3](#) when I present results about sex differences in overall intelligence.

Sampling Issues

There are several sampling pitfalls that are exacerbated in or unique to sex differences research. Five of these issues are considered here: comparable between-sex samples; sample size; inappropriate generalizations; age by sex interactions; and replication samples.

Comparable between-sex samples Sex differences research is concerned with ways in which women and men, on the average, differ. Even though we may want to know about all women and men in North America or in Bolivia or in the world, we can only collect data from a sample or subset of the population in which we are interested. The people we actually use in our study must be representative of the population we want to know about if our generalizations are to be accurate. Consider the issue of mathematical ability. One common approach to the question of whether males or females exceed in mathematical ability is to administer mathematical aptitude tests to males and females who have attained a given level of mathematical training. For example, a researcher might examine sex differences on the mathematics portion of the SAT (SAT-M), which is commonly used for admission to universities. As you will see in the next chapter, on average males score higher on the SAT-M. But, are the samples comparable? This may seem like a strange question given that so many people take this exam for college admissions, but in fact many more women take the SATs than men. Can you think how this might affect the average scores for men and women?

Suppose for example that the top one third of women in math ability take the SAT-M and the top one quarter of men take this assessment. If that were true, then we would expect the average scores for women to be lower than those for men, even if there were no differences between the men and women. We really do not know how the sample of women and men actually differ, except that there are many more women than men who take the SATs. When many more women than men take a test like the SAT-M, then the average score for the women would be lower than that for the men, even if there were no overall average differences or no differences in the scores for the top quarter of each group. Thus, it is easy to overlook the many ways that samples can be nonequivalent and when they are, the results from the research are likely to be flawed. Similarly, we cannot study children and make generalizations about adults or the reverse because there are too many differences between children and adults to assume that a finding with one age group will necessarily apply to another age group.

Statistical techniques that control for sampling differences provide some useful information. Suppose again that researchers found that one group scores significantly higher than the other group on some test of mathematical ability. It would be possible to determine if there is a relationship between the number of math courses taken and scores on the Advanced Placement test, for example. If this relationship were found, and if one sex takes more math courses (again,

on average), then the researcher could show that sex differences in mathematical ability tests can be explained on the basis of course taking alone. Despite these advantages, research that utilizes statistical control procedures still begs the basic question of why there are differences in mathematical achievement tests and in the number of mathematics courses taken by boys and girls. Some research methods (analysis of covariance) could be used to conclude that the sexes would be equal on this hypothetical test of math ability if they took the same number of math courses. The problem with conclusions like this one is that it is like asking if poor people would vote like rich people if they were not poor. Even if the researcher found that they would, this result would be of little immediate value because the poor people are still poor, and therefore will continue to vote for issues that concern the poor, despite the statistical control we've gained over our data with this technique.

Quite simply, the results obtained from any study depend on the subjects who are selected for the study among many other variables. People vary along countless dimensions—educational level, age, socioeconomic status, motivation, to name a few. It is important to keep the nature of the sample in mind when interpreting research results.

In sex differences research there is no easy answer to the dilemma of sampling. If you were interested in determining whether cognitive abilities vary over the menstrual cycle, who is the appropriate comparison group? Is it women who are not menstruating (either because they have reached menopause or because of a hysterectomy or medications that suppress the cyclical change in hormone concentrations) or is it a group of men or is it the same women measured at different points in their menstrual cycle? Studies that have investigated the possibility that women become more aggressive during the premenstrual phase of the menstrual cycle seem to ignore the fact that men commit many more acts of aggression every day of the month.

Sample size A second sampling problem in sex differences concerns sample size or the number of subjects we need to include in an experiment. In general, large samples yield good estimates of population parameters (true values in the population). One of the major factors concerning sample size is the amount of variability in the population from which the sample is drawn. If the population has little variability (i.e., there is very little spread among the scores) then a small sample will provide a good estimate of the population parameters, whereas a population with considerable variability (i.e., scores are spread out and do not cluster tightly around a mean value) will require a larger sample size in order to obtain stable estimates of its parameters. One theory in the sex differences literature is that male performance is more variable than female performance. (This hypothesis is discussed in more detail in [Chapter 3](#).) If this hypothesis is true, then we would have to sample more males than females in order to obtain the same level of confidence in our statistics. This is virtually never done in practice, nor have I ever seen it addressed as a sampling issue.

The number of subjects selected for a study has important implications for the conclusions we can draw. Although large samples are desirable because they yield good estimates of population parameters, they also virtually insure that statistically significant sex differences will be found. For mathematical reasons, small samples are less likely to provide evidence of sex differences than large ones. Many of the studies that fail to find differences use a small number of subjects. The experimenter who is honestly seeking answers to sex differences questions will have to be concerned with sample size. Far too frequently, the issue of sample size is ignored or resolved on the basis of hunch or intuition. Ideally, all sex differences research (and other research) should begin with an estimate of the size of the sex difference effect that would be important to detect. For example, a researcher studying sex differences in intelligence might decide that a sex difference of less than two IQ points would not be important in understanding differences in cognition. The two point difference would then be converted into an “effect size” (discussed in more detail later in this chapter). It is then a simple procedure to solve a mathematical equation for determining how many subjects should be included in the experiment. The fact that statistical significance depends so heavily on sample size is one reason why there seem to be so many contradictions in the research literature.

Inappropriate generalizations A third issue in sampling concerns the use of atypical populations. Very frequently, researchers sample from abnormal populations to formulate conclusions about normal women and men. This approach is most commonly used in research that examines the effect of chromosomes and hormones on the cognitive abilities of normal women and men. The reasoning behind this approach is that by examining what happens when something goes wrong (e.g., extremely high concentrations of male hormones on developing fetuses), we can understand the role of the variable being investigated under normal circumstances (e.g., the effect of normal levels of male hormones on developing fetuses). There is an obvious flaw in this approach. First, abnormal populations differ from normal ones in many ways. An infant exposed to abnormal concentrations of prenatal hormones may develop a masculine body type or may receive specialized medical care or unusual treatment by family members. The secondary effects of the hormone anomaly may affect the variable under investigation and these effects could be mistakenly attributed to the hormone rather than the experiential factor. Thus, it is not possible to isolate the influence of hormones per se. In addition, abnormal hormone levels (or chromosome patterns or any other variable that is atypical) may have effects that are unrelated to the effect of normal hormone levels (or chromosome patterns). Research with abnormal populations can provide supporting or confirming evidence for a hypothesis, but cannot be used as the primary support of a hypothesis.

Often, researchers concerned about understanding human sex differences conduct their research with other animal species. The major difficulty is

generalizing from rats or monkeys to humans. We know that hormones, for example, play a greater role in the behavior of nonhuman species than they do in humans, while cognitive and social variables are more important in determining human behavior. Generalizing from animal research to humans is also difficult because contradictory results are obtained with different breeds within a species. Thus, while animal research can provide information that is interesting in its own right, extreme caution is urged when extrapolating the results to humans. For example, Janowsky (1989) studied the brain mechanisms that underlie song behavior in canaries. Male canaries, but not females, exhibit a complex learned song behavior. When researchers administer testosterone (a male hormone) to female canaries, female canaries will develop the song behavior of male canaries. Research of this sort suggests that testosterone plays an important role in the development of canary song behavior. We cannot use this sort of data to conclude that testosterone is important in human verbal behavior because there are too many differences between human and bird brains and between canary songs and human verbal behavior. Nevertheless, this research is not “useless.” It does suggest that, at least for some animals, testosterone plays a role in vocalization. Like research with abnormal human populations, research with nonhuman animals can provide supplemental support for relevant hypotheses and can suggest new areas of research, but it cannot support a hypothesis without more relevant evidence.

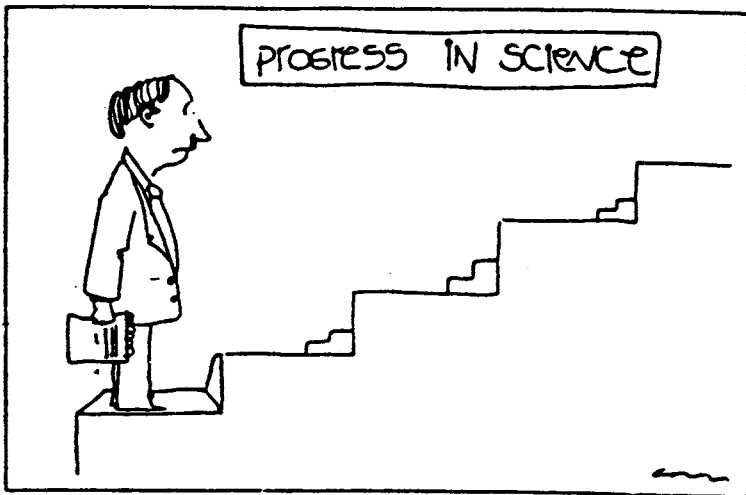
Age by sex interactions Another issue in selecting subjects is age. It is likely that some sex differences change over the life span and in different ways for each sex. A difference may be nonexistent in childhood, emerge during puberty, and disappear again in old age. Some abilities decline at different rates for elderly men and women. The answers we find to sex differences questions are age dependent. Research that utilizes only young adults in college (the favorite subject pool of academics because of ready access) will undoubtedly fail to capture the age-dependent nature of any differences that exist.

Age is a complex variable because there are other variables, called cohort variables, that occur with it. A cohort is a group of people who, because they were born at the same time, share the same experiences. A 75-year-old woman who spent her young adult years during the horrors of World War II, may have received very little formal education, and if she drives a car, she probably learned later in life than most 75-year-old men. If we were to find that older women are less able to read maps than an age-matched group of older men, it would be difficult to disentangle the effect of sex from the effects of aging, a lifetime of sex-differentiated experiences, and systematic differences in formal education.

In general, researchers have tended to ignore the developmental nature of adult age differences in cognition. Overwhelmingly, college students have been used as subjects in cognitive research. Thus, we also know very little about sex differences in cognition for the majority of the population who never

attended college. Because our cognitive abilities do not remain static throughout the life span, generalizations about sex differences that may be true at adolescence or young adulthood may be false for mid-life or older adults. The elderly remain one of the most understudied populations for cognitive sex differences, despite the fact that understanding sex-related developmental differences is crucial in an aging society and the proportion of the population who is elderly is increasing at a rapid rate.

Replication samples Because all research is necessarily probabilistic, sometimes spurious reports of sex differences will be found in the literature. The ultimate test of whether a report of a sex difference is real is whether it is replicated (that is, does it reliably appear) in other experiments. Good researchers are aware of this test and plan replications of their own work before they publish sex differences results. A replication sample is a second or third sample of subjects who are similar to those used in an original study. These subjects receive essentially the same experimental manipulation (if there is one) and have the same measurements taken as those in the original sample. If sex differences are also found in the second or third sample, then we can accept the results with greater confidence than if they were found only in one sample. Although replication samples are always a good idea, they are especially important in research that doesn't employ the random assignment of subjects to conditions because research of this sort provides weaker evidence than true experiments. Unfortunately, few reports of sex differences are based on research with replication samples.



Measurement

Measurement is defined as the assignment of numbers according to rules. The way we measure or assign numbers directly influences the kinds of results we obtain. One of the major measurement issues that sex differences researchers need to be concerned with is how sex should be measured. This may seem like a surprising question if you are not familiar with the problem. Usually, sex is measured as a dichotomous (two choice) variable with every subject being either male or female. However, there are many times when it is desirable to measure the degree of maleness or femaleness. For most of us, the usual indicators of sex are in agreement. Our chromosomes, hormones, genitals, gonads, sex of rearing, and self-definitions all agree that we are either male or female. However, this is not always true. Consider the anomalous case in which chromosomes may indicate maleness, but genitals and sex of rearing are female. Is this person somehow “less male” and “less female” than the typical male or female?

Part of the measurement problem is that it is not always clear what researchers mean by *sex*. Although, as explained in [Chapter 1](#), I have decided not to make this distinction, sometimes sex is used to refer to biological differences with the term *gender* used for referring to the social construction of sex. The components of biological sex are usually, but not always, consistent, but gender identity, sexual preference, and gender role are sometimes inconsistent with each other and with biological sex. These variations of sex make it difficult to think of sex as a single variable.

A more common dilemma with regard to dichotomous versus continuous measurement concerns sex-role conformity. This concept refers to the extent to which an individual's behavior conforms to the female or male sex role as defined in a given society. That is, does one conform to sex-typed expectations or stereotypes? The question of whether sex-role conformity should be dichotomous (i.e., men and women could be either masculine or feminine in sex-role orientation), discrete with three or four possibilities (masculine, feminine, androgynous, or undifferentiated), or continuous (more or less masculine or feminine) has been the subject of heated debate. Humphreys (1978) has argued that masculinity/femininity requires continuous measurement and Baucom and Welsh (1978) argue that a dichotomous (extreme groups) level of measurement is appropriate. Continuous measurement generally provides more information and may be preferred when measuring other variables like handedness in which one can be more or less right- or left-handed instead of dichotomously right- or left-handed. However, both types of measurement are useful in assessing sex differences. It may be that the extremely masculine individual is qualitatively, not just quantitatively, different from a feminine individual. It seems that both dichotomous and continuous measurement can be used depending on the nature of the question being asked.

Ceiling and floor effects are another measurement problem that can distort our understanding of sex differences and similarities. Let's start with an example. Suppose you want to know if there are sex differences in mathematical abilities. To test this possibility, you get a random sample of high school students and give them a test of addition and subtraction. As you might expect, both the women and men in this sample perform extremely well—both groups get close to 100% of the arithmetic problems correct. Does this mean that there are no sex differences in mathematical abilities? The problem in this example is a “ceiling effect.” Both groups scored “at or near the ceiling” or top of this measure. It may be that one group is better than the other, but the measure is not sensitive enough to “pick up” the difference. Similarly, suppose you decided to investigate possible sex differences in mathematics and used a random sample of girls and boys in fourth grade. This time, you decide to use a calculus test—a subject that is not taught until the last year of high school. What sort of results would you expect? Everyone is likely to score close to zero, in this case, the “floor” or bottom score. It is also likely that there would be no sex differences because both the girls and boys scored so low.

It is easy to “see” ceiling and floor effects in these examples, but they can be harder to spot in real research. For example, in [Chapter 7](#), I discuss an international study of sex differences in visuospatial ability. Across 53 countries men scored higher than women on two different tests of visuospatial ability. But, on one of the tests, the mean difference between men and women was very small for participants from Pakistan. It may seem surprising that there should be more equal performance among women and men in Pakistan than in any of the other countries, but a careful reader will see that it is because both men and women score very low on that test—in other words, the results are most likely a floor effect (even though careful readers will note that lower scores are possible, this is still most likely a floor effect) and not an indication that women and men are equal in their visuospatial ability in Pakistan.

Date of Publication and Sex of Researcher

You may be wondering what the date of publication or sex of researcher has to do with understanding the results of research. Several experimenters have investigated the possibility that sex differences are diminishing over time. One way to do this is to find if results that were published in the 1940s showed larger sex differences than those published in the 1950s and so on. While it is logical to assume that researchers would report smaller and smaller sex differences over time if the size of the difference is diminishing, there is a major problem with this line of reasoning. There are many changes that occur with time. For example, if we were to measure reading ability among college freshmen over the last fifty years, we would have to consider the fact that the nature of college freshmen has changed in numerous ways. Fifty years ago, it was fairly unusual for women to enroll in college; those that made it into

college were more likely from wealthy homes or were exceptionally intelligent or persistent. This is not true today. Over half of all college first-year students are women, so the group of women who are in college today is different in many ways from women college students fifty years ago. Research that has used date of publication to argue that sex differences are decreasing or increasing will be considered in detail in [Chapter 3](#).

Sex of researcher is an even more subtle variable than date of publication. The reason that some people think that the sex of the researcher is important in understanding results is because there are numerous ways, both deliberate and unintentional, in which investigators bias the outcomes of their research. If we were to assume that more women are feminists than men, then we might expect that women researchers are more likely to provide results that are consistent with feminist philosophies than men who conduct similar research. We all interpret the world in terms of our own backgrounds and experiences. This does not mean that all research is biased or that we cannot keep an open mind and evaluate findings in a fair manner, only that we need to consider the ways in which personal beliefs can bias the outcomes of research. Over 20 years ago, Hyde and Linn (1988), for example, found that female researchers were more likely to find evidence of female superiority in verbal abilities than male researchers. International and other standardized data are used more often today in investigating cognitive sex differences, so I doubt that this finding would hold true for most of the currently published research. In an ideal world, sex of researcher would be an irrelevant variable.

Moderating and Situational Variables

We are all social creatures. The way we respond in any situation depends much more on environmental factors than individual factors. If you are sitting in a college classroom, shopping in a supermarket, or getting up in the morning, I can predict what you are doing with pretty good accuracy, without knowing anything about you. Situational variables are extremely potent in determining behaviors. Researchers frequently study sex differences by controlling all factors other than sex of the subject. Suppose you wanted to study nurturing behavior to decide if females are more nurturing than males. Eagly (1987) pointed out that research conducted in carefully controlled laboratory settings often finds that there are no sex differences in nurturance. But, if the same researchers were to investigate nurturing behavior in more natural settings (caring for sick children, assisting the elderly), they would find that women occupy more of the nurturing roles in society. Thus, setting is a salient part of any research report.

It is important to keep in mind that all behavior occurs in a context. Almost everyone will agree that people often respond in different ways in different situations. This may be especially true of sex-related differences. Suppose, for example, that you are interested in sex differences in assertive behavior.

Furthermore, you are aware that results obtained in laboratory settings may not generalize to the real world. So, you decide to examine assertiveness in a public place. Suppose, further, that you choose to study sex differences in assertiveness at the movies. You carefully note that in mixed sex dyads (pairs in which one member is female and the other member is male) the male usually drives to the movies, purchases the movie tickets, hands them to the ticket taker, and yes, even makes the important popcorn decisions (battered or unbattered). Based on this naturalistic observation, you would conclude that males are more assertive than females. However, you would have failed to study other situations in which women tend to be assertive, such as dealing with a child's angry teacher, returning defective merchandise, handling an emergency at the office, or negotiating the sale of a residence as a real estate broker. You probably recognize each of these scenarios as stereotypically female, yet, you may never have realized that each requires assertiveness, a stereotypically male trait.

Experiments conducted in laboratory settings often involve artificial situations. Because so much of our behavior is situation dependent, it is important to consider ways in which the experimental situation may have biased the results. This is an important point in understanding sex-related cognitive differences. Men, for example, may not perform as well on tasks that are viewed in our society as feminine (e.g., embroidery) when they are being observed as they do when performing the same tasks in private. Sex of experimenter is an important situational variable, which is often overlooked. Subjects sometimes respond differently to same-sex and other-sex experimenters.

It is easy to see how situational variables can influence the results we get. In Rankin and Eagly's (2008) paper on heroism, they found that people reported more males than females who were public heroes, but when they were asked to name heroes they knew personally, women and men were mentioned in equal numbers. In discussing these results, the experimenters noted that when people thought about heroic acts, they tended to think about acts that people perform in a social role such as being a police officer or fire fighter, roles that are predominantly male. But when thinking about their personal lives, people tended to think about situations in which people acted as family guardians, and in those situations, men and women were equally likely to be named as heroes. Thus, the situation or context in which a research question is couched can have very different effects on the outcomes of the research.

Multivariate Indicators

An examination of sex-related differences in cognitive abilities requires that both sex and cognitive abilities be measured. In most research with normal populations, sex is measured by self-report. Virtually all people define themselves as either male or female, although as already discussed, sex can be measured in other ways (e.g., more or less masculine or feminine). The

measurement of cognitive abilities is more problematic. If you want to investigate spatial ability, for example, how can you measure it in a meaningful way?

A clear definition of what constitutes spatial ability is needed. There is often disagreement among researchers, each of whom tends to work with a somewhat different definition (Chatterjee, 2008; Hegarty, 2010; National Research Council, 2006). There is a wide variety of tasks that rely on spatial abilities—navigating in a forest without clear landmarks, navigating in a city with clear landmarks, using blueprints to visualize what a building would look like, and keeping a visual representation in memory in order to accomplish a task. These are all tasks that require spatial abilities, but do they all draw on a single underlying spatial skill or are they separable, perhaps separate dimensions? There are literally hundreds of tests that can be used to measure spatial ability, and, as you can imagine, they do not all yield the same results. Some of the tests commonly employed include the performance section of the Wechsler Adult Intelligence Scale (WAIS), finding simple figures that are embedded in larger ones, imagining how a figure will look if it is rotated in the depth plane, figuring out how the surfaces of a cube would fit together if a flat diagram were assembled, tracing a route on a real or imaginary map, and assembling a model from written instructions.

The problem for the researcher is to decide which of these tests will yield a *true* measure of spatial ability. It is usually possible to eliminate some tests on an a priori basis because they fail to meet certain criteria. Some of these tests may actually rely heavily on verbal skills or be inconsistent with working definitions of spatial abilities. There is probably no single ideal test. If a researcher wants to explore sex differences in spatial ability, then several tests of spatial abilities should be employed in the same experiment.

Multiple indicators of cognitive abilities are desirable for several reasons. If sex differences in the same direction are consistently found on four different tests of spatial ability, then a more convincing claim that differences exist can be made than if differences are found on one test. Second, if sex differences are found on some tests of spatial ability, but not others, the experimenter can examine ways in which these two types of tests differ, yielding a more fine-grained analysis of the nature of sex differences. A hypothetical example of the way several tests could be used to isolate the nature of the sex difference is the finding that the sexes differ on tests that require short-term memory of spatial information, but not on other tests of spatial ability. These results would suggest that the location of spatial ability differences is in spatial memory and not the ability to utilize spatial information *per se*.

Sometimes researchers use multiple indicators and then inappropriately use univariate data analytic techniques. For example, a researcher might use ten different tests of spatial ability, then analyze each test separately to determine if sex differences exist. The use of multiple univariate analyses increases the probability that a researcher will find sex differences that are due to chance

sampling differences. Multivariate statistical techniques (e.g., MANOVA) are often needed when multiple indicators are used.

STATISTICAL AND PRACTICAL SIGNIFICANCE

Statistical calculation is a mathematical process, whereas the interpretation of effect sizes is an act of human judgment.

—Larry V. Hedges (2008, p. 170)

In order to understand research results, the reader must consider both the statistical and practical significance of any mean (average) difference between males and females. Let us begin with an example to clarify this point.

Suppose that a researcher wants to know if boys or girls watch more television. He carefully samples children within a given age range, socioeconomic status, etc., and then tallies the number of hours of television watched by each child in a week. He then computes the mean (average) number of hours of television watched by the boys and girls in the sample. Suppose that he finds that boys watch an average of 25 hours of television a week and girls watch an average of 25.4 hours a week. Obviously he cannot simply look at these two mean values and conclude that the sexes differ with respect to average amount of television viewing. These differences could be due to chance. Conclusions based on simply *eyeballing* the data are humorously called “binocular tests of significance.” All serious researchers require a statistical test of significance.

Because research in sex differences always involves samples of people and because people are variable, there is always some chance or probability that conclusions based on the research are incorrect. There is very little in life, and especially in sex differences research, that is known with absolute certainty. It is important to keep in mind the probabilistic nature of research results. Suppose that 100 studies are conducted comparing the number of hours of television watched by boys and girls. If we set $p < .05$ (it would happen by chance less than 5 times in 100), then by chance alone, even if boys and girls watch television the same number of hours each week, 5 of these studies would find sex differences. Furthermore, if only studies finding sex differences appear in the published literature, then it is easy to see how incorrect conclusions are reached. There is no simple remedy for the fact that sometimes researchers will find sex differences “just by chance.” Tests of statistical significance constitute the backbone of research. They are essential in interpreting research results; however, they should be considered as a first step in making sense from the results.

When research results are statistically significant, it is correct to conclude that there probably are differences between the sexes, especially if the results

can be interpreted in a theoretical framework and have been replicated with different samples. Given these results, a second question should be, “Is the difference large enough to have any practical significance?” In other words, are the results meaningful or useful? This is the most important question to ask of research results. Considering the current example, the researcher and reader need to ask if the finding that girls watch, on the average, 0.4 of an hour more television each week than boys has any practical significance. Clearly it would be incorrect to construe this difference as implying that girls are glued to television sets while boys are off doing other things. The obtained mean difference translates into an additional 24 minutes a week or 3.4 minutes a day! Even if such a result were statistically significant, it tells us very little of any practical importance about boy/girl differences in television watching. There is a type of statistics known as effect sizes that can be used to quantify the strength of a relationship between variables (Hedges, 2008). But, the decision of whether an effect size is large enough to be important is a matter of human judgment.

Variability and Shapes of Distributions

The idea that males are intellectually and educationally more variable dates back a long time and is embedded in cultural history.

—Stephen Machin and Tuomas Pekkarinen (2008, p. 1331)

In order to understand if a sex difference exists with respect to a particular variable, the investigator needs to be concerned with the distribution of scores for women and men because the relative number of each sex that obtains a particular score on a test has important implications for the way we interpret the data. The distribution of scores refers to how spread out or how variable they are. Variability is often indicated with a measure called a standard deviation. Most of the scores will be within one standard deviation of the mean, with few scores more than two standard deviations from the mean (either above or below the mean). There are many ways distributions can differ in their mean and variability. Consider the seven hypothetical distributions of scores in [Figure 2.3](#).

The hypothetical distributions in [Figure 2.3](#) depict some possible outcomes for men and women on a test of musical ability. [Figure 2.3A](#) represents the case in which men and women obtain an identical distribution of scores, with most subjects obtaining a score of 50 on this test (the mean or average), and a few obtaining scores as extreme as 0 or 100. The finding that both sexes have the same distribution of musical ability is seen by the overlapping identical curves. Both curves show the same peak (corresponding to the mean of the distribution in normal distributions) and the same bell-shaped curve (indicating that they have the same variability or “spread-outness” of scores).

[Figure 2.3B](#) shows a somewhat different distribution of female and male scores. In this case, the sexes have the same mean score (the *average* for both

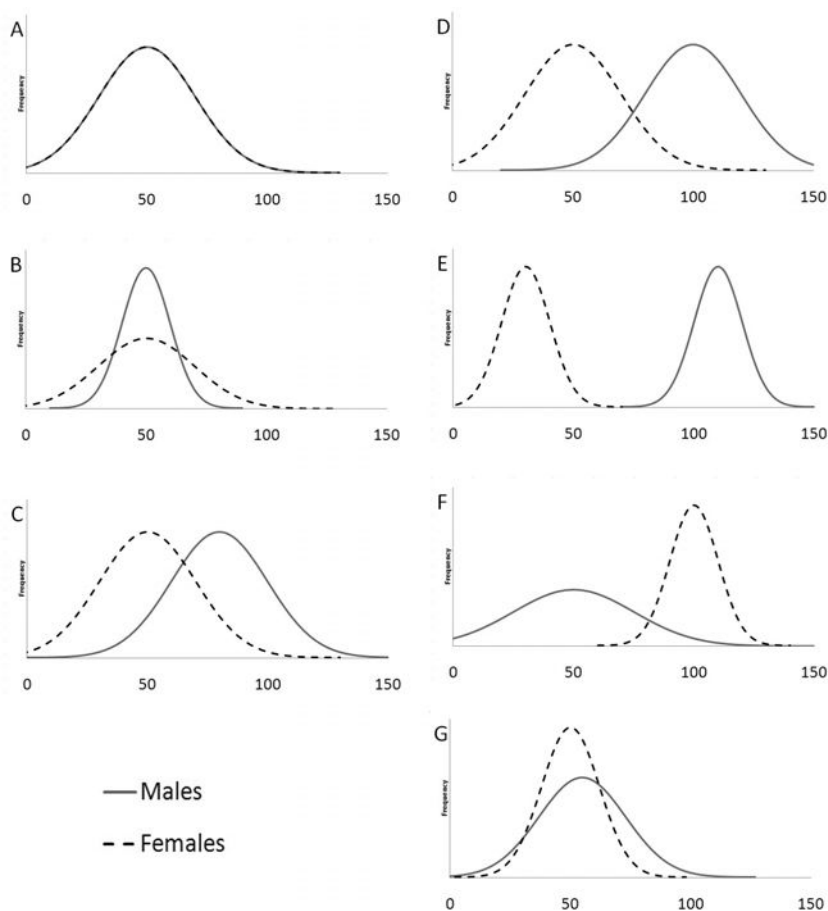


Figure 2.3 Seven hypothetical distributions of male and female scores on a test of musical ability.

women and men is 50), but the sexes differ in variability. In this hypothetical distribution of scores, the male scores are more closely clustered around the mean, indicating less variability for men than for women. Thus, any man selected at random would be expected to be near the mean value in musical ability while any women selected at random would be expected to be farther from the mean (either lower or higher) than her male counterpart. This also means that if we were only interested in people who have very high levels of musical ability, then there would be more women than men, even though there is no difference in the average musical ability for these two groups.

Figures 2.3C, D, and E all depict situations in which the means between the sexes differ (in this case with males, on the average, outperforming females), but

the variability remains about the same. There is much overlap between the sexes in [Figure 2.3C](#), an intermediate amount of overlap in [Figure 2.3D](#), and virtually no overlap in [Figure 2.3E](#). While each of these scenarios represents a case in which a researcher could legitimately conclude that males scored higher in musical ability than females, each figure tells a different story about the distribution of musical ability by sex. If [Figure 2.3E](#) depicted the true results for males and females, then we would expect the most tone deaf males to have more musical ability than the most musically talented females. On the other hand, if [Figure 2.3C](#) represented the true distribution, then we might expect only slight differences in the percentage of women and men at every level of musical ability.

[Figure 2.3F](#) represents another possibility. In this figure the female and male distributions have both different means and different variances. In this hypothetical example, females scored higher than males and showed less variability. If [Figure 2.3F](#) were a true representation of these distributions, then we could expect more females to score well on this test and to score close to the female mean while men would be more variable with some obtaining low scores and others high scores.

Look closely at the last figure, [Figure 2.3G](#). This figure shows that the mean score for the males is slightly higher than the mean score for the females, and there is more variability for the men's distribution of scores than for the women's distribution of scores. In this case, the difference in average scores is small, but it gets magnified in high and low ends because males are more variable. As it turns out, this sort of distribution will be important in understanding the cognitive sex differences discussed in [Chapter 3](#). As these possible distributions show, it is important to consider the shape of the distribution of scores when exploring sex differences.

Mean Differences and Tail Ratios

Although most of the research on sex differences reports mean (average) group differences between women and men, there is increasing interest in the variability of scores, and it is critical to think about variability when considering cognitive sex differences. If a researcher is only considering mean differences between groups, then the report is not very useful because information about the variability of scores is just as important as mean differences in understanding cognitive sex differences. With increased interest in the variability of distributions, researchers need to consider the percentiles of males and females at every ability level. A report that women excel at verbal reasoning tasks is less meaningful than one that also indicates, for example, that 75% of women and 70% of men scored at or beyond a given score on the test. The additional information presents a clearer picture of the distribution of this ability between the sexes and allows a more meaningful comparison.

A related issue is the way researchers report measures of central tendency, which are indicators of what value best represents most of the scores. Most

report group means as a single number summary of the scores obtained by each sex. Although this is useful, and probably essential, in understanding what the data represent, mean values should also be reported along with confidence intervals, which are a range of scores that probably contains the true population mean. It would be more meaningful to know that the population mean for women in a hypothetical aptitude test is probably between 85 and 115 while the comparable confidence interval for men is 87 to 117 than it is to know that the sample mean for women is 100 and the sample mean for men is 102. (In a more statistical vein, confidence intervals are computed for selected confidence levels, such as 95%, and can be interpreted as meaning that if the experiment were repeated 100 times, 95% of the intervals computed would contain the true population mean.)

Sometimes, the difference between the means of two distributions (in this case, samples of females and males) is small, but the difference in the tails or extreme ends of the distributions is large. For this reason, several researchers (Hedges & Nowell, 1995) suggested that, in addition to reporting mean differences, all research concerned with sex comparisons should also report tail ratios. (Readers with a good background in mathematics will recognize tail ratios as one type of likelihood ratio.) To understand tail ratios consider the upper (or lower) tail of a distribution, let's say the top 5% on a particular test of mechanical aptitude. If 1,000 people took this test, then 50 would score in the top 5%. (If we were concerned with the bottom 5%, there would also be 50 people in the lower tail and the same logic would apply.) Suppose that of the 1,000 subjects (or test-takers in this example), 750 were male and 250 were females. Among those scoring in the top 5%, 39 were male and 11 were female. To calculate the upper tail ratio, you would compute

$$\begin{array}{rcl} \frac{\# \text{ males in top 5\%}}{\# \text{ males in sample}} & = \frac{39}{750} & = 0.052 \\ \frac{\# \text{ females in top 5\%}}{\# \text{ females in sample}} & = \frac{11}{250} & = 0.044 \\ \hline & & = 1.18 \end{array}$$

What this number means is that for every female in the top 5% on this hypothetical test, you would expect to find 1.18 males. Of course, males come in whole numbers only, but these are statistical averages. It is easier to think of these data as saying that for every 100 females who score in the top 5% of all test-takers, there are 118 males. Tail ratios are especially important in understanding data when the tests are used for selection purposes. In these cases, only those who score above some cut-score get selected (usually for employment or college admissions). For example, a college may only admit students with a 950 or higher on the SAT; 950 is the cut-score. Sometimes, tests are used to identify those who would benefit from a special program, and lower tail ratios are important in these cases. There are many data sets where the mean difference between males and females is small, but the differences in

the tails of the distributions are large. If the purpose of the test is to select individuals who score above or below a particular score, then tail ratios need to be considered.

Meta-Analysis

The literature on sex differences is enormous. How can anyone sift through thousands, perhaps even tens of thousands, of research reports to determine which of the reported differences is *real*? No single experiment can ever provide the answer to sex differences questions. In an area as complex as this, researchers need to consider the preponderance of results before stating a conclusion. One of the best known and earliest attempts to synthesize the literature on sex differences was undertaken over 35 years ago by Maccoby and Jacklin (1974). They tallied all of the studies investigating sex differences that had been published in American journals during the 10-year period prior to 1974. They set a criterion that sex differences existed only when a large number of studies found sex differences in the same direction for a given variable. Although this was the first major attempt to synthesize the sex differences literature and thus made a significant contribution to the literature, their procedure has been criticized as the “voting method.”

A more sophisticated technique of integrating research findings is meta-analysis which, as its name implies, is the analysis of analyses, or an analysis of many individual research results. It provides a measure of the strength or importance of a relationship between two variables. The need for meta-analysis is obvious in a research area in which the size of the literature can be measured in linear yards or pounds of paper generated. Meaningful integrations of research findings are the best way to interpret the voluminous literature. The purpose of meta-analysis is not only to determine how many studies obtained sex differences results in the predicted direction, but also how large the differences between women and men were.

Despite the obvious advantages of meta-analysis, like almost all research and statistical methods, there are also drawbacks. One problem is that the analysis does not differentiate between studies that are done well and those that are shoddy or sloppy. All studies are not equally good, so all results should not be considered equal. An even more important criticism is that a meta-analysis might correctly summarize studies and conclude that there are no average differences between females and males, but completely miss critical differences in variability. If the male scores are more variable, even if the means are the same as the female scores, there will be more males at both ends of the distribution. This problem could be handled by computing a meta-analysis at different points along the distribution, for example are the means of the top 5% of all females and males the same? Although a meta-analysis at different points along the distribution of scores is a logical way of looking at tail differences, it is rarely done.

The File Drawer Problem

Meta-analysis allows us to take a broad overview in summarizing research results (Rosenthal & Rubin, 1982). It is important that the individual studies that are analyzed with meta-analytic techniques be representative of the research in the field. A major problem is finding representative research. The most logical place to find research is in the journals and books found in libraries; however, due to publication practices, there is a bias to publish only studies that have found evidence of sex differences. Suppose that 100 researchers investigated sex differences in cognitive styles and that 90 of them found no differences. Suppose further that of the 10 that found differences, 2 found differences that favored men and 8 found differences that favored women. Given the current publication practices, it is more likely that the 10 studies that found sex differences would get published than the studies that found no differences. Suppose further that a researcher who is eager to understand the nature of sex differences in this area attempts to perform a meta-analysis. She would most likely use only published studies in her analysis. After all, how would she even know about the unpublished studies which could have been conducted in universities and other settings around the world? If the eight studies supporting female superiority found even moderately large sex differences, meta-analysis statistics would support the conclusion that females have better cognitive styles than males, a conclusion that may be unwarranted in light of the 90 studies that found no sex differences.

Fortunately, there are a few sources that allow access to unpublished research reports. Doctoral dissertations are usually available through *Dissertation Abstracts*. Education-related research that appeared as paper presentations at conferences or other unpublished presentations are available in ERIC (an educational information retrieval service). Anyone who is contemplating a meta-analytic review of an area should be sure to search these sources for research so that unpublished experiments are included. While inclusion of these sources of data will help to ameliorate some of the bias associated with publication practices, it is also true that papers that report significant group differences are more likely to be accepted for presentation at a conference than research reports that fail to find differences. Doctoral dissertations presumably reflect a concerted effort to obtain statistically significant results. Thus, there is probably no truly unbiased data source.

Meta-analysis has been criticized for its use of unpublished research on the grounds that unpublished research tends to be poorer in quality than published research that has undergone the peer review process. As explained earlier in this chapter, there are many ways to obtain null results, including shoddy research. If the peer review process has any merit at all, then those studies that are published should, on the average, be of a higher quality than those that are rejected for publication. Thus, a major criticism of meta-analysis is that it

weighs good and poor research equally instead of somehow adjusting for the quality of the research.

The tendency to publish primarily statistically significant results has been declining in recent years, with more journal editors judging the quality of research apart from its results. It is, however, very difficult to judge the quality of research when the results are not statistically significant. Null results are almost impossible to make sense out of because it is not easy to determine why the researcher failed to find differences. Certainly, one possibility is that there are no differences between females and males with respect to the variable being studied. Although a single finding of null results doesn't mean much, numerous carefully conducted studies with large sample sizes, conducted by many different investigators at different laboratories, certainly do provide evidence that if there are any sex differences, the differences are exceedingly small.

How can anyone summarize a large body of research when the studies that are available for scrutiny are biased toward those that report statistically significant differences? This question has come to be known as the "file drawer problem." The term "file drawer problem" refers to all of the studies that found null results and were never published. As the name implies, the underlying idea is that the results of these studies are languishing in file drawers in various laboratories. We can never know how many studies that are unavailable did not show evidence of sex differences. One way to handle this problem is to examine all of the available studies, and if the researcher concludes that there are sex differences with regard to some variable, then she would also calculate the number of null results that would be needed to change her conclusion. For example, suppose a researcher summarized 35 different studies of sex differences in cognitive styles and concluded that females have a more introspective cognitive style than males. (This is a fictitious example.) The researcher would then compute the number of studies with null results that would be needed to change her conclusion to "no sex differences." The actual number of null results that would change the conclusion depends on several variables including the size of the difference, a topic that is discussed in detail later in this chapter. She would then add to her summary the finding that 20 (or whatever number is calculated) studies that found no between-sex differences would be needed to alter her conclusion. In this way, researchers can acknowledge the possibility that there are unpublished null results. The number of "file drawer" studies needed as counterevidence to a conclusion that a difference exists is a meaningful number. Suppose that a researcher determined that there would have to be 300 studies that found nonsignificance that were never published to change his conclusion that there are sex differences with regard to some ability. Because this number is so large, we could confidently conclude that there really are differences between men and women with regard to the ability that was assessed.

Effect Size Statistics

Despite the fact that effect size statistics have been available in the literature for decades, they are finally being reported in almost every study, in part because the publications standards usually require that researchers report an effect size statistic. Effect size statistics are extremely important in understanding the extent to which sex plays a role in cognitive abilities.

Four statistics that are used to determine the importance or size of the experimental effect are ω^2 (omega squared), d , binomial effect size display, and r . Each has a somewhat different meaning and use, although all four are used in understanding how much the sexes differ with respect to a given variable. Each of these measures is described separately below and then compared so that readers can meaningfully grapple with the question, “When does an effect size become important?”

ω^2 (omega squared) In order to understand the meaning of ω^2 , we need to reconsider variance, which is a measure of the variability in a set of data. Variance is a measure of how dispersed or spread out the individual scores in a data set are. If the scores are very spread out, the variance for that sample will be large; whereas if the scores are closely clustered, the variance for that sample will be small. If everyone in a study had exactly the same score, there would be no variability, and variance would be equal to zero. ω^2 is a measure of the proportion of total variance in a data set that can be explained by a particular variable, in this case, sex of subject.

Consider the following hypothetical example. If we asked a sample of young and old women and young and old men to respond as quickly as possible to a set of stimuli, we would usually find that the older subjects took longer to respond than the younger ones. We might also find sex differences, depending on the type of stimuli we employed. Suppose that in this hypothetical study we also found that men responded more quickly overall than women. The first test of the data would be to determine if the differences between age groups and sexes are likely to have occurred by chance when in fact there really are no differences between men and women in the general population. If we found that the results we obtained would have occurred by chance alone less than five times in one hundred, then we would conclude that the results were unlikely to be due to chance; therefore, real differences probably exist between the age groups and sexes. This type of test is a test of statistical significance. Virtually every research report includes a test of significance. Finding statistically significant results should constitute the first step, not the final step, in data analysis.

In the hypothetical example being considered, some of the variability is due to the fact that two age groups of subjects were used. If the differences in the age groups account for most of the variability in the data, then the proportion of total variability due to age will be large. Conversely, if there are large differences in the scores obtained by women and men, then ω^2 will be large for

the sex variable. If ω^2 for sex is large, then if we know an individual's sex we could use this knowledge to predict his or her ability to perform the task. If ω^2 for sex is small, then knowing an individual's sex will yield poor predictions about her or his ability on the task. (Readers with a strong background in statistics know that eta squared is usually used when describing a sample and ω^2 is used when describing a population, but the differences are not important for this discussion and thus ω^2 is being used in this general discussion.) When two or more variables are investigated in the same experiment, the ω^2 associated with each variable can be compared to determine, for example, whether sex or age is more important with respect to the ability being investigated. In a meta-analysis, ω^2 is computed for each of several experiments investigating the same ability. An average (median) ω^2 is computed from the values obtained in each of the studies. In this way, research results from many experiments on the same topic can be summarized with a single measure of the average effect size.

A major limitation in interpreting ω^2 or any proportion of explained variance statistic is that the value obtained depends on the other variables investigated in the experiment. ω^2 for sex in an experiment that investigated sex and age variables will not be comparable to the ω^2 for sex in an experiment that investigated sex and socioeconomic variables. Because ω^2 depends on the other variables in the experiment, across-experiment comparisons can only be made when the same set of variables are investigated in different studies.

d Another statistic used to index the size of an effect is *d*. It is a measure of the magnitude of the difference between two groups. *d* is a standard mode of expressing the difference between two group means based on standard deviation units, which means that you need to understand the concept of standard deviation to understand a measurement standard that is based on it. As previously described, a standard deviation is a measure of how spread out a distribution of scores is. *d* is computed by calculating the difference between means on a given variable for men and women and then dividing by the standard deviation. When variables are normally distributed (i.e., they show a regular bell-shaped curve), approximately 32% of all scores fall between the mean and one standard deviation above (or below) the mean, 16% of all scores fall between 1 and 2 standard deviations from the mean, and 2% of all scores fall more than 2 standard deviations above (or below) the mean. A standard deviation is a measure of variability. It is equal to the square root of the variance.

The most widely used measure is Cohen's *d* (1977):

$$d = \frac{\bar{X}_f - \bar{X}_m}{\sqrt{\frac{SD_m^2 + SD_f^2}{2}}}$$

where $\bar{X}_f$ is the mean for female group and $\bar{X}_m$ is the mean for male group, and SD_f and SD_m are the respective standard deviations for females and males.

The value of d will be large when the difference between means is large and the variability within each group is small; it will be small when the difference between means is small and variability within each group is large. Unlike ω^2 , d provides a measure of the direction of an effect. Thus, if we compare d from several different studies, a positive value will indicate that males scored higher than females and a negative value will indicate that females scored higher than males as long as the female mean is always subtracted from the male mean. In general, large values indicate large sex differences, and small values indicate small sex differences.

Effect sizes are given in standard deviation units because different studies often used different scales of measurement. For example, SAT scores range from 200 to 800 on each test; whereas, intelligence test scores average around 100 (with the lowest scores in the 30s and highest scores just above 200). By using d , it is possible to compare female and male scores on both of these tests. In thinking about effect sizes, it is useful to consider a graph of the differences or some other visual display that can make this abstract idea more concrete. Unfortunately, the way the graph is drawn can make the same size effect appear large or small, and it is important for readers to understand the way they can be misled by graphical displays. Consider a hypothetical test of honesty in which the mean is 100 and the standard deviation is 15.

Now suppose that the average score for girls on this test is 107.5 and the average score for boys is 100. If we use the formula for d , this is expressed as

$$\frac{100 - 107.5}{15} = -0.5$$

This indicates that the means for the girls and boys are 0.5 standard deviation units apart. The negative sign means that the girls scored higher in this example. Cohen (1977) suggested that effects sizes of 0.2 be considered small, 0.5 medium, and 0.8 large. Although this is a simple guideline, it is a misleading interpretation of effect size because sometimes a small effect can be very important. For example, an effect size of 0.2 in medical research can mean the difference in hundreds or hundreds of thousands of lives saved or lost, depending on what is being studied and how many people are affected. As Halpern, Benbow et al. (2007a, b) have argued, seemingly small effects can have great practical importance. The question about when an effect size is large enough to be important is critical in many studies of cognitive sex differences. As you will read in [Chapter 6](#), this is at the heart of a contentious disagreement over whether the Advanced Placement test used to award college credit for courses taken in high school (and, by extension, other high stakes tests) are biased against females (Danaher & Crandall, 2008; Stricker & Ward, 2004, 2008).

Meta-analysis also allows tests of homogeneity of effect sizes from several studies. If, for example, half of the studies in a particular area showed large effect sizes favoring males (positive values for d) and half showed large effect sizes favoring females (negative values for d), it would not be logical to conclude that, on the average, there are no sex differences with regard to the variable being studied. When a test of the homogeneity of an effect size shows that the results are not homogeneous, then the reviewer is not sampling from a single population. In other words, moderator variables are causing the differences, and the studies should be subdivided into homogeneous subcategories. To clarify this concept, let's consider another example. Hyde (1986) conducted a meta-analytic review of sex differences in aggression. Because her test for homogeneity showed that aggression is not a homogeneous (uniform) concept, she subdivided the studies into meaningful categories. Hyde used "age of subject" as one of her subdivisions and found that "gender differences are larger with younger subjects" (p. 63). (In case you're wondering, she found that there are "no types or measures of aggression on which females are more aggressive than males" [p. 63], although females may be more aggressive with "indirect measures" and in "relational aggression," which refers to threatening one's relationship with the target individual.) I'll return to the concept of homogeneous types of studies in the next chapter when I examine the empirical evidence for sex differences in cognition.

Binomial effect size display Because both ω^2 and d are somewhat advanced statistical concepts, Rosenthal and Rubin (1982) suggest that the size of a difference between any two groups is best understood with a "binomial effect size display" (BESD). The BESD is the percentage of each sex that is above the average in the combined group of females and males. These values are readily comprehensible and do not require any statistical training to be understood. Binomial effect size displays are similar to tail ratios because they index the proportion of females and males in the tails of the distributions, except that they are probably easier to understand. Unfortunately, very few researchers have employed this statistic in their report of their research.

In a thoughtful discussion of the effect of small differences in "real world" outcomes, Martell, Lane, and Emrich (1996) used a computer simulation to show the cumulative effect of seemingly small effect sizes. They asked readers to consider a hypothetical situation in which women's work is evaluated less favorably than men's work even when it is objectively the same. They hypothesized that the devaluation of women's work is relatively slight, so that it accounts for only 1% to 5% of the variance in the data. They also considered the pyramid structure of most organizations in which promotion is accomplished in "tournament style," with early ratings influencing the likelihood of reaching top management positions. For their simulation, they set up a model with 500 incumbents at the bottom of the organization, 10 at the top, and 8 levels of promotions. The highest scorer at each level gets the promotion.

They found that with sex bias accounting for “only” 5% of the variance overall, only 29% of all top workers would be female compared with 58% of the bottom-level workers. The point is that relatively small sex effects in performance ratings can cause substantially reduced promotion rates and disproportionately fewer women at the highest levels of organizations. In this example, they used binomial effect size statistics to communicate the cumulative effect of small effect sizes. Because of the intuitive nature of these statistics, I think that they made a strong point about the importance of effect sizes.

R^2 When we compute a correlation between two variables, the resulting statistic is r . When computing correlations among several variables, we use a capital R . When two measures are related so that increases in one are related to increases in the other, for example, height and weight, they have a *positive correlation*. Although height and weight are positively correlated, we cannot infer that gaining weight causes people to grow taller or that growing taller causes people to gain weight. In understanding the relationship between two correlated variables, it is possible that variable A caused the changes in variable B ($A \rightarrow B$), or that variable B caused the changes in variable A ($B \rightarrow A$), or both A and B caused changes in each other ($A \rightarrow B$ and $B \rightarrow A$), or that both were caused by a third variable C ($C \rightarrow A$ and $C \rightarrow B$). If we want to understand the size or strength of the correlated relationship, we square the value of r .

When Is an Effect Size Large?

Even if a researcher computes the value of ω^2 or the other effect size indicators, the reader is still left with the task of deciding if the value reflects a “large” or a “small” effect, or, more accurately, whether the obtained effect size is large enough to be important. This is not an easy decision to make because it involves a value judgment about how large an effect (difference between groups) has to be to be considered meaningful or important. As I explained in the first chapter, the answer to this question is the same answer that I give to all difficult questions in life: “It all depends.” The trick is deciding what it depends upon. In medical research, an extremely small effect size can have enormous importance. If someone were to discover a drug that allows a small number of people with AIDS to recover from this dreadful disease, everyone would agree that it was an extremely important drug. If you were one of the people who recovered from AIDS, you would not care if the effect size was extremely small.

Comparing Effect Size Indicators

In order to decide if an effect size is large enough to be meaningful, you have to understand what the numbers mean. Unfortunately, these values are not

intuitive. In the next chapter, I give the values obtained by females and males on the SATs and do not convert them to an effect size. These are numbers that are readily meaningful to most college students because they were required to take these tests. Other numbers, like average differences in reaction time tests (how quickly someone responds to something, which is usually measured in milliseconds or thousandths of a second) or number correct on a finger tapping task (this will be explained later), are much more abstract. When you read about research, you'll have to consider if the results were statistically significant, whether the effect size is large enough to be theoretically important, and even if both of these conditions are met, whether the effect is large enough to be practically important.

Eagly (1987) has compared effect size indicators for several differences in social behavior. Let's consider differences in aggressive behavior. She reported that sex differences account for only 2% of the variance in aggressive behavior. (This is ω^2 .) This certainly sounds like a very small effect. The corresponding $d = 0.29$, or slightly less than one third of a standard deviation. This is conceptually a "small" effect according to the guidelines suggested by Cohen. However, when we examine the binomial effect size display, the effect size seems much larger—43% of the females and 57% of the males scored above average of the measures of aggression. These three indicators of effect size all apply to the same set of data. The value of ω^2 seems quite small while the binomial effect size display seems quite large, even when they are describing the same set of data.

Eagly (1987) also computed three different effect size indicators for Hall's (1985) report of sex differences in social smiling. Sex of subject accounted for 9% of the variability in social smiling. The corresponding value for $d = 0.63$. By comparison, the BESD showed that 63% of the females and 35% of the males scored above the average for social smiling. The point that I want to make by comparing these three different indicators of effect size is that even when sex differences account for a small percentage of the variability in the data, the BESD can be quite large.

A study of sex differences in activity level provides another example for comparing effect size indicators. Eaton and Enns (1986) concluded that males have a higher activity level than females. The size of the sex difference in standard deviation units is $d = 0.49$ (almost one half of a standard deviation). This difference accounted for approximately 5% of the variability in activity level. Eaton and Enns calculated that there would have to be thousands of unpublished studies showing null results (the file drawer problem) to render this result nonsignificant.

According to Rosenthal and Rubin (1982), an effect that accounts for only 4% of the variance is associated with a difference of 60% versus 40% of a group's performance above average. If there were a test such that an individual must score at least average in order to qualify for employment, then 60% of one group and 40% of the other group would qualify. When considered this

way, it is easy to see how 4% of the variance can translate into huge between-sex differences that are of practical importance. Try to keep this in mind when evaluating research results.

The Interaction of Variables

One of the main themes of this book is that finding answers to sex differences questions will not be easy, nor will the answers be simple. The cognitive abilities that women and men develop depend on many variables. It seems likely that our abilities are influenced by age, birth order, cultural background, socioeconomic status, sex-role orientation, learning histories, etc., in addition to the simple fact that we were born either female or male. In reality, these variables work together in their effect on cognitive abilities. It is possible, for example, that wealthy females who are first born tend to develop excellent verbal ability, whereas lower-middle-class females who are second or third born do not tend to develop these same excellent abilities (perhaps because the first born wealthy female is talked to and read to more often). In this example, the influence of sex depends on the levels of other variables. A host of socio-demographic (e.g., age, place of residence), psychological (e.g., motivation), biological (e.g., health status), and life history (e.g., level of education) variables operate in conjunction with sex to determine the level of each cognitive ability that an individual obtains. The term *interaction* is used to denote the fact that the effect of sex differs depending on the value of other variables (e.g., low, middle, or high socioeconomic status). Recall also that many variables mutually affect each other. For example, a stressful environment can cause an increase in the body's output of some hormones, and the increase in hormones can cause certain reactions that change behavior, which in turn increases hormone levels, etc. It is important to consider any research on sex differences in light of the other variables that could be influencing the results. Understanding the manner in which sex interacts with other variables will provide a richer and more meaningful interpretation of the way maleness and femaleness influence cognitive development than merely considering the main effect of sex alone.

Structural Equation Modeling

A useful statistical technique known as structural equation modeling (SEM) is often used when researchers want to know about causal links among multiple variables. The mathematics of SEM is beyond the level of this book, but everyone should be able to look at an SEM diagram and understand the main ideas that are being tested. Suppose that we want to understand academic achievement in some area, let's say mathematics. This is not a hypothetical example since there are many research studies that attempt to do just that.

The extent to which someone will achieve at a high or low level, or anywhere in between, depends on many different variables. With SEM, the researcher specifies which variables are important and will usually measure all of the variables in several ways. Let's consider the SEM shown in [Figure 2.4](#). This figure is taken from an article written by Neuenschwander, Vida, Garrett, and Eccles (2007). These researchers tested the idea that someone's achievement in mathematics (they also studied other types of achievement, but they are not relevant for this example) could be understood by knowing about the expectations their parents had for their achievement. Look at the boxes and arrows in [Figure 2.4](#). Start with the box labeled "Parents' expectations." You will see that there are two arrows that point to this box; arrows coming from "SES" (socioeconomic status) and "Academic marks." According to this model, parents' expectations for the achievement of their children in mathematics are caused by (or determined by) the parents' SES and the academic marks the children get in school. Notice that there is a two-headed arrow between SES and academic marks; this shows that the researchers believe that these two variables influence each other. Although the relationship is not shown in this model, by reading the text you would learn that they expect that the higher the SES, the better the academic marks. In other words, these two variables go together. The box labeled "Self-concept" shows that someone's self-concept about their ability in mathematics is affected by the academic marks they get in school and their parents' expectations. Finally, achievement is determined (in part) by someone's self-concept.

Thus, one diagram shows different relationships among five variables and which variables are hypothesized to influence the other ones. The researchers measure each of the constructs, usually with more than one measure, and then put the measures together in one statistical model. They then test how well the data they collected support the model. In this case, the data fit the model well, and the researchers concluded that parents' expectations and academic marks affect self-concept, which in turn affects achievement. In other words, the

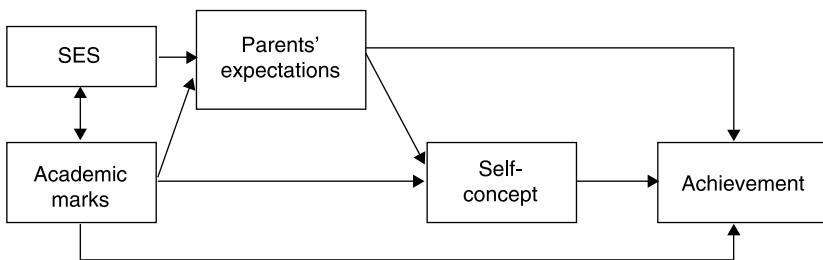


Figure 2.4 An example of a structural equation model for understanding achievement. From Neuenschwander, Vida, Garrett, and Eccles (2007). Copyright © 2007 by SAGE. Reprinted by permission of SAGE.

researchers could make good predictions about achievement by knowing about the relationships among the other four variables, and how they relate to each other to influence achievement.

DEVELOPMENTAL ISSUES

Cognitive abilities, like physical abilities, do not remain static across the life span. Different activities follow their own developmental course, reflecting the influences of age-dependent biological and sociological changes. Sex differences may appear and disappear depending on the age of the subject. The welter of contradictory evidence in the literature makes it clear that there can be no useful answer about sex differences in any cognitive ability without reference to the ages of the subjects.

Cross-Sectional Versus Longitudinal Studies

If cognitive abilities wax and wane across the life span, developmental studies will be needed to understand the phenomena involved. Developmental studies are usually either cross-sectional (sampling at random from different subjects in several age groups) or longitudinal (repeatedly measuring the same individuals at several ages as they mature). Sometimes combinations of these techniques are employed when, for example, several age groups are measured repeatedly over 5 or more year-periods.

A major problem with cross-sectional studies is the cohort or peer group effect. As described earlier, the cohort effect refers to the fact that people who are the same age also had similar age-dependent experiences. Consider, for example, the following problem: A researcher wants to know about age-dependent changes in the ability to read maps (a spatial skill). Using cross-sectional samples, she tests men and women in their early 20s, mid 40s, and late 60s. Suppose she finds that there are no sex differences in the young group, small differences favoring males in the middle-aged group, and large differences favoring males in the oldest group. Could she conclude that sex differences favoring males develop throughout the adult years? She could not make this conclusion because experiences with reading maps of the oldest women are probably different from those of the middle-aged women, who in turn had different experiences than the young women. As explained earlier in this chapter, it seems likely that the oldest women have fewer years of driving experience—an activity that often requires map reading—while many of the middle-aged women and virtually all of the young women drive on a regular basis. By contrast, virtually all of the men in all three age groups drive regularly, thus having similar experiences with maps. The age-dependent sex difference in map reading is more likely due to cohort or generational experiences than it is to life span changes in abilities. It may be that the young

women will maintain their map reading skills into old age so that when they are in their late 60s they will perform in a manner comparable to their male counterparts.

Cohort effects, which are always possible in cross-sectional developmental research, are especially likely to contaminate developmental data in sex differences. Women's roles are changing rapidly (men's roles are changing also, albeit more slowly) and it is therefore difficult to control experiential factors across generations. Generational differences in the experiences of women and men will make any determination of why the differences exist very difficult.

Longitudinal research also has drawbacks associated with it. When subjects are measured repeatedly throughout their life span, it is always possible that earlier testing experiences influence later ones. There is also the problem of subject loss due to death, moving out of the area, refusal to continue, and other reasons. It is likely that the lost subjects differ from those who continue in subtle ways (e.g., they may be less able). Finally, longitudinal research will take years to provide answers. If you want to study changes that occur from birth into old age, your children or grandchildren will have to collect the last of the data because the study would extend beyond a single lifetime.

SELF-FULFILLING PROPHECIES

A large body of literature exists to document the finding that experimenter expectancies often influence research results. One of the pioneers in this area was Robert Rosenthal, who is famous for his work in the area of self-fulfilling prophecies. This term refers to the concept that experimenters and others will often act in ways that influence results so that the outcome is in accord with their beliefs. In a classic study (Rosenthal, 1966), elementary school teachers were told that some of their pupils had obtained high scores on a special test designed to measure intellectual development. Intelligence tests given later in the school year showed that the "bloomers" had made greater gains in IQ points than the "nonbloomers." The teachers reported that the bloomers were more interested, more curious, and happier than the other children. What is remarkable about these results is the fact that the children identified as "bloomers" had been picked at random and, therefore, did not differ from the other children. Somehow, the teachers had communicated their expectations to the children, who in turn responded to these expectations.

Sex differences research is particularly vulnerable to experimenter and subject expectations. If an experimenter believes that females will outperform males on a particular test, he or she may unknowingly act friendlier toward the females (or males) or provide them with a little more encouragement or allow a little extra time in completing the test. Subject expectations also influence results. If, for example, girls believe that mathematical ability is unfeminine, it

is likely that they will reflect this belief in their performance. The girls could give up easily on the more difficult problems because they do not believe that they could solve them, or even deliberately select wrong answers in order to maintain a feminine self-concept.

In reading research reports, it is difficult to detect ways that either experimenter or subject expectancies biased the results. One way to circumvent this problem is by having the data collected by researchers who are *blind* to or uninformed about the hypothesis being investigated. Subjects should also be unaware of the fact that sex differences are being examined. Experiments in which the sex of the subject is unknown to the experimenter will also eliminate the effects of sex-related experimenter expectancies. This is possible, however, only in research with young children and research that doesn't require face-to-face interaction between the researcher and subject. (Young children could dress in standard smocks or jeans that don't provide the experimenter with clues as to the child's sex.)

Research in the area of sex differences is particularly vulnerable to self-fulfilling prophecies. In Fausto-Sterling's (1985) discussion of the way beliefs can bias research, she asks that every researcher understand that, by definition, no one can see her or his own blind spots. For this reason, every research report should provide enough information so that readers can identify possible biases in research.

It is not necessarily true that simply because someone maintains a philosophical position, he or she is unable to conduct research or formulate conclusions in a fair manner. Readers, regardless of their personal beliefs about the issues discussed in the following chapters, are asked to maintain an open mind and to consider the evidence on all sides of the issues.

EVALUATING RESEARCH CLAIMS

The purpose of this chapter was to raise issues that are important in evaluating research claims about sex differences. In evaluating conflicting claims or strong statements, keep in mind the following issues:

- 1 Who were the subjects and how were they selected? Is the sample size appropriate for the question being examined? Are results from abnormal populations or other species being generalized to all women and men? Are studies of adults being used to make statements about children or vice versa?
- 2 Are studies that employed neither random assignment of subjects to conditions nor manipulation of any variables inferring causal information?
- 3 Is the measurement appropriate? Could any finding of no difference be caused by ceiling or floor effects? Have multiple indicators of abilities been used, and if so, were the data analyzed with multivariate statistical techniques?

- 4 Are the results both statistically significant and practically significant? How large is the effect size?
- 5 Has detailed information about the distribution of scores within each sex been provided? Did the researcher provide information about the data both at the means and in the tails?
- 6 Has the way sex interacts with other variables in determining the results been investigated? What alternative explanations are plausible?
- 7 How might the results vary across the life span? Have cohort effects been included as a possible explanation of the results?
- 8 Are the results reported consistent with the prior literature and/or theory of sex differences? If not, why not? Do the results fit into an established theoretical framework? If not, why not? Were the hypotheses clearly stated before the data were collected? Have critical studies been conducted that would allow the proposed theory to be found false?
- 9 How could the results have been influenced by experimenter and subject expectations?
- 10 Is the size of the effect large enough to be meaningful given the questions being studied?
- 11 Are the results logical and understandable?

The literature on sex differences has been proliferating in recent years. Although much of it is thoughtful and high in quality, some of it is not. The goal of finding answers to the broad, complex, and socially and politically sensitive question of sex differences is of profound importance. The informed reader will have to evaluate the research with an open mind and an awareness of what constitutes good research.

Empirical Evidence for Cognitive Sex Differences

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Chapter Summary

INTELLIGENCE

Are men smarter than women? The answer to the above burning question is: No, they are not. Data are now being laid on the table that show that, on average, men and women are equal in mental ability.

—Dan Seligman (1998, p. 72)

The first question most people ask about sex-related cognitive differences is which is the smarter sex—males or females? Although this question has a long and acrimonious history, the question of who is the smarter sex has persisted for at least as long as modern measurements of intelligence have been possible and probably long before then. There are several ways to find answers for this question. One logical way is to obtain large random samples of women and men, give them a psychometrically sound intelligence test (one with good statistical properties), and compare the scores for women and men. The sex with the higher average score would be the smarter sex. Although this may seem like a logical, straightforward approach to answering the question of sex differences in intelligence, it won't work. Intelligence tests are carefully written so that there will be no average overall difference between men and women (Brody, 1992). During the construction of intelligence tests, any question that tends to be answered differently by males and females is either discarded or balanced with a question that favors the other sex. Even though intelligence tests are revised repeatedly to reflect changes in the population, all changes are carefully considered so that they do not benefit men or women as a group. Therefore, average scores on intelligence tests cannot provide an answer to the sex differences question because of the way the tests are constructed.

A second way to decide whether men or women are, on average, smarter might be to look at who performs the more intelligent jobs in society. Of course, one would have to decide which jobs require greater intelligence. Suppose that most people could agree in principle that jobs like government leader, architect, lawyer, physician, professor, mathematician, physicist, and engineer all require a high degree of intelligence. An examination of who performs these jobs would reveal that the overwhelming majority of these jobs are held by men. Does this mean that men are, in general, more intelligent? Looking at the types of jobs typically performed by women and men in society cannot provide an answer to the intelligence question because of differential sex roles for women and men. Many professions were formally or informally closed to women until recent years. Similarly, there are few male nurses, secretaries, and child care workers because of the constraints imposed by the male sex role. There are still considerable socially related differences between the sexes in background experiences, types of encouragement, amount and type of education, and social expectations for success. We cannot know if the differences in the numbers of men and women

in the various job classifications are related to overall intelligence differences or to differential socialization practices or to some combination of the two. This issue is discussed in greater depth in the chapters on psychosocial hypotheses ([Chapters 6 and 7](#)).

A third way of answering the intelligence question is to look at school achievement. Which sex, on the average, gets better grades in school and is more likely to obtain advanced degrees? Numerous sources of data clearly show that women get better grades in school than men in every subject area, although the differences are not large. The U.S. National Center for Educational Statistics found that across elementary and secondary schools, females consistently receive higher grades than males in the classroom (Snyder, Dillow, & Hoffman, 2009). Other studies confirm this general conclusion. For example, one large-scale study of high school grades found that the average grade point average (GPA) was 2.83 for boys and 3.05 for girls (using a 4-point scale; U.S. Department of Education, 2004). As students move into college, women continue to get better grades, on average, than men: 61% of females and 49% of males have a college GPA higher than 3.0 (Clune, Nuñez, & Choy, 2001). Paradoxically, girls get better grades than boys even in “traditionally male” content areas, such as mathematics and physics, in which boys score higher on tests used for college and graduate school admissions such as the SATs and Graduate Record Exams (GREs; Coley, 2001). [Figure 3.1](#) shows the combined high school GPA for girls and boys in the United States from 1990 to 2005. Note that although there is a consistent advantage for girls in grades, the difference is generally small, about 0.23 of a grade on a 4.0 GPA.

Although girls achieve higher grades on average in science and mathematics courses in high school, boys achieve higher scores on average on Advanced Placement (AP) examinations that are written to test knowledge of high school course materials. Many colleges will accept a score of 3 or higher as equivalent to college-level achievement in the subject that was tested. Sex differences in science and mathematics AP tests are shown in [Figure 3.2](#).

The data favor the intelligence of females when looking at course grades, and they favor males when looking at most high stakes exams such as the Advanced Placement tests and SATs. As you will see as you read through this entire text, it is often true that whenever some data seem to provide a clear picture and understanding of cognitive sex differences, other data provide an equally compelling and a diametrically opposed view and understanding of the same phenomenon. Consider, as another example, the percentage of men and women who attain college degrees. As explained in [Chapter 1](#), in the United States and most western countries, men are attending and graduating from college at higher rates than ever before (Mead, 2006). But the steady increase in men’s increasing college-going rates since the 1970s to the present has been eclipsed by the much greater rise in women’s college-going rates. Women’s rates had a sharp rise in the 1970s and a small but steady increase in the 1980s

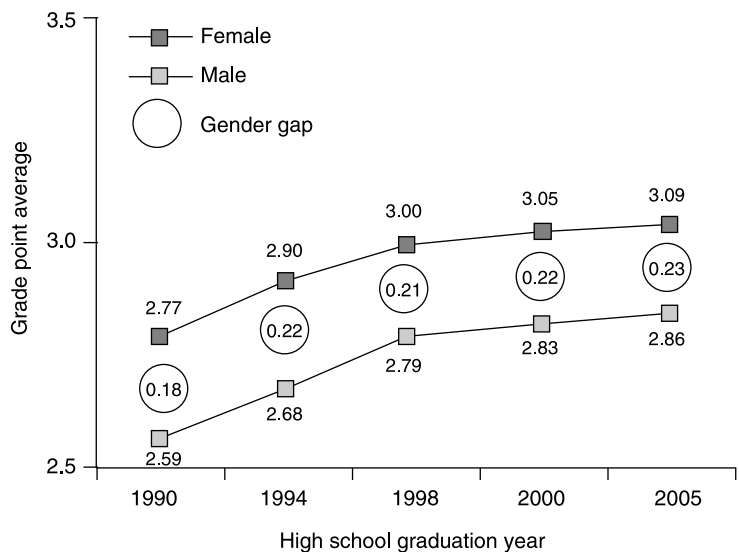


Figure 3.1 High school grade point averages for girls and boys in the United States from 1990 to 2005. From U.S. Department of Education, National Center for Education Statistics (2007b).

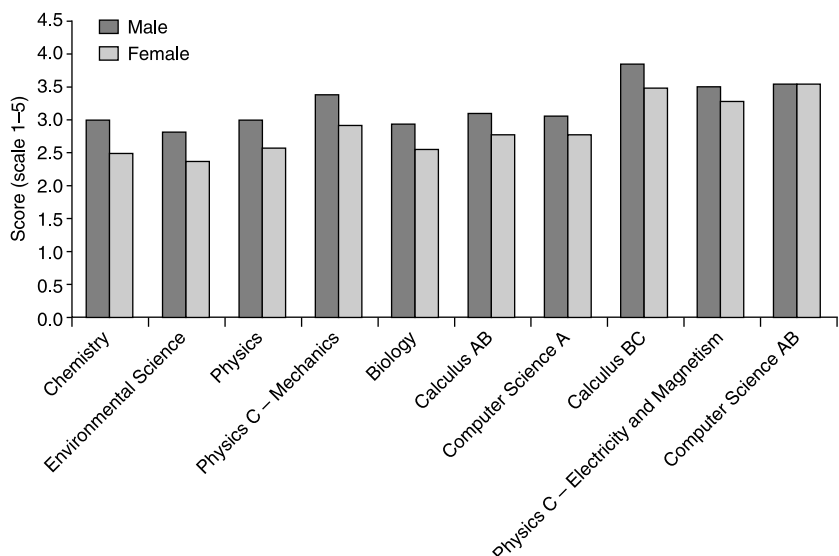


Figure 3.2 Average scores for males and females on Advanced Placement examinations in science and mathematics for 2009. From National Summary Report 2009. Copyright © 2010 The College Board. Reproduced with permission. www.collegeboard.com.

and beyond. Despite the higher rate of women attending and graduating from college, women are not selecting college majors that allow them to enter the higher-paying, more prestigious jobs at the same rate as men. There has been a large increase in the percentage of bachelor's degrees earned by women in biology (60%) and the agricultural sciences (60%), chemistry (52%), and mathematics (45%), with most degrees going to men in physics (79% male), engineering (80%), and computer science (80%; data from Hill, Corbett, & St. Rose, 2010, p. 9). There are large differences in the areas that men and women select as college and graduate school majors.

Consider graduate degrees in the sciences—there are many different kinds of sciences and the graduation rates of women vary widely among them. In the U.S. women are obtaining 50% of the MD degrees from medical schools, almost 78% of the DVMs from veterinary medical colleges, and 44% of dental degrees (Burns, 2010). The data for U.S. veterinary college enrollments are shown in [Figure 3.3](#).

Clearly women are selecting careers and succeeding in some sciences. So, it is NOT a lack of cognitive ability for success in science that is responsible for their underrepresentation. Careers in the sciences and math can accommodate a wide range of abilities. Women are not achieving equally in all areas of science. In contrast, men make up a minority of enrollments in many of the majors that lead to careers in the helping professions such as clinical psychology, education, and nursing.



Figure 3.3 Data showing the change in veterinary school enrollment in the United States from 1970 to 2011. Figure from Burns (2010). Reprinted with permission from the Association of American Veterinary Medical Colleges.

There Are Data and There Are Interpretations of Data

It has long been known that it is possible to create or eliminate differences in test scores by selecting different test items.

—Beatriz C. Clewell and Patricia B. Campbell (2002, p. 264)

There are many types of information that researchers and the general public can use to decide whether women or men are the smarter sex. Even though many people consider it an unanswerable question that is best considered “a draw” given data that sometimes support the superiority of women and sometimes support the superiority of men, it is a question that just will not go away, probably because there are a handful of researchers who steadfastly maintain that women are less intelligent than men, and they seem to get coverage in the media with every pronouncement of male superiority. The superiority of males has been the consistent position of Rushton and his colleagues (who, by the way, also maintain that Blacks are less intelligent than Whites and Whites are less intelligent than Chinese; e.g., Rushton & Jensen, 2006). I hope that you are wondering what sort of data they use to support this contention.

As already explained, all of the major intelligence tests have been written so that there is no overall sex difference. The equality of intelligence test scores has been well known since 1942 when a leading intelligence test, the Stanford–Binet, was revised to “produce a scale which will yield comparable IQs for the sexes.” After initial testing found women tended to score higher than men, the authors concluded that “intellect can be defined and measured in such a manner as to make either sex appear superior” (McNemar, 1942, p. 42). According to McNemar, “test developers sought to avoid using test items showing large sex differences in percentage passing” (p. 45) so they could produce a scale that would yield comparable IQs for males and females. In other words, the most important variable in determining whether females or males score higher on intelligence tests is the type of question that is asked.

Despite the fact that intelligence tests are written to show no overall sex differences, Jackson and Rushton (2006) claimed that males had a 4-point advantage on intelligence tests. They based this claim on calculations they made using the SATs, where in fact, males do achieve higher average scores than females. There are numerous reasons why SAT data cannot be used to decide that either sex is smarter. One problem with using SAT data to determine whether females or males are smarter is that many more females than males take the SATs; approximately 55% of SAT-takers are female. As explained in [Chapter 2](#), when a greater percentage of one sex takes any assessment, especially a test that is used for college admissions, it is likely that more people from that group are “less-elite” than from the group with the smaller participation rate. We return to the SAT data in several places throughout this book because they play a central role in understanding how and when females

differ in their cognitive abilities and because scores on the SATs are used, in part, to decide who gets admitted to competitive colleges and universities.

There are some researchers who report a small advantage for males on tests that were standardized to show no sex differences (Nyborg, 2005), but most do not (e.g., Colom, Garcia, Juan-Espinosa, & Abad, 2002; Deary, Thorpe, Wilson, Starr, & Whalley, 2003). In a recent review of the question of sex differences in intelligence, Dykiert, Gale, and Deary (2009) found that reported sex differences on intelligence tests can be explained by the use of samples that are not representative of females and males in general and, thus, reflect errors in the methods used to study this question. This conclusion was confirmed by Hunt and Madhyastha (2008) who provided a mathematical model of the subject selection problem that occurred in studies that report sex differences in intelligence. Hunt and Madhyastha concluded that there are numerous problems with studies that report sex differences in intelligence.

There are logical problems with any claim that one sex is smarter than the other. First, standardized measures of intelligence cannot be used to support this claim because one cannot use a test that was deliberately constructed and tested with a large standardization sample to ensure that there would be no overall sex differences to then support the conclusion that there are sex differences. Second, the conclusion that males are smarter than females ignores the many other sorts of mental measures on which females score higher than males, such as grades in school, writing tests, and many types of memory assessments. Any similar conclusion with females as the smarter sex faces the same logical problems because there are many areas that males excel in, as described later in this chapter.

In an interesting twist, Jensen (1998) joined the debate over sex differences in intelligence. Jensen is no stranger to heated controversies about intelligence. In a 1969 paper, he asserted that African Americans are, on average, less intelligent than European Americans, a position that he has maintained to the present. As a means of addressing the question of male–female differences in intelligence, Jensen analyzed tests that “load heavily on *g*” (*g* is the generally accepted term for general intelligence). In his analysis, Jensen used only tests that had not been deliberately written to eliminate sex differences, thus making it more likely that he would find evidence for sex differences in intelligence, if they existed. Jensen used five different test batteries for which he had large, representative samples that encompassed the full range of ability in the general population. Jensen concluded, “No evidence was found for sex differences in the mean level of *g* or in the variability of *g*. . . . Males, on average, excel on some factors; females on others” (pp. 531–532). A study of the intelligence of children in Belgium and the Netherlands confirmed Jensen’s conclusion that there are no sex differences in overall intelligence, although sex differences are found on some subtests (van der Sluis, de Jong, & van der Leij, 2007).

Perhaps the most important lesson to be learned from this debate is that researchers, like the rest of us, maintain a particular world view that they use

in interpreting research findings. This point became clear to me during a recent discussion of these issues that I had with a developmental psychologist. After I explained to him that females get higher grades in school and males get higher scores on (some) standardized tests of cognitive abilities, his face brightened. He filtered this information according to his own world view and exclaimed, "That proves that schools are biased against boys." "Perhaps," I responded. "But it could just as easily be used to 'prove' that the tests are biased against girls." This is a good example of two contradictory explanations of the same findings—each of us making the leap from data to our interpretations of data via our privately held world views.

The problem with questions like "which is the smarter sex" is that they begin with the assumption that there *is* a "smarter sex." The research reviewed in this book suggests several areas in which sex differences are consistently found and other cognitive areas where sex differences are not found, but in no way does this mean that one sex is the "winner" and the other the "loser," or that one sex is smarter and the other is dumber. The more meaningful questions are when, where, and why are cognitive sex differences found. Modern society is complex and diverse. There is no single best set of intellectual abilities for all of society's tasks. It is important that we come to think of differences apart from value judgments about who and what is better. If society consistently values the abilities that are more frequently associated with one sex, then the problem lies in the way differences are valued, not in the fact that they exist.

A more fruitful approach to the cognitive sex differences question is to examine specific abilities, especially in light of the fact that intelligence is not a unitary concept. It is theoretically more useful to think of multiple "intelligences" than to consider intelligence as a single homogeneous mental ability. The question then becomes, "What are the sex differences in cognitive abilities?" Although intelligence tests are constructed so that there will be no overall sex difference in intelligence, the tests do differ in the pattern of intellectual abilities for the two sexes. Surprisingly, in an area as controversial as this one, there is little disagreement about which of the cognitive abilities differs by sex. As you will see, the most heated debates revolve around whether the differences are large enough to be important and why these differences exist.

THE WHEN, WHERE, WHO, AND HOW OF DIFFERENCES

Although there are no overall differences in intelligence between males and females, sex-related cognitive differences are found consistently on tests of some cognitive abilities. Between-sex differences show an uneven pattern of results that often depend on the portion of the ability curve being sampled

(e.g., gifted individuals, low ability, or the average-ability range), the age of the sample (infancy, preschool, middle childhood, adolescence, adulthood, old age), the response format (multiple choice, essay, diagram), and probably many other variables, including socioeconomic status and the gender equality and level of economic development of the society in which people live. What this means is that simple answers that apply to all females and all males are impossible. In addition, the size of the between-sex difference depends on other moderating factors, such as education, home environment, testing conditions, personal and societal beliefs, and many more.

Tails of Distributions

As introduced in [Chapter 1](#), researchers and commentators in the area of cognitive sex differences can be thought of as “difference maximizers” or “difference minimizers” (Wai, Cacchio, Putallaz, & Makel, 2010). Researchers who stress findings that show that males and females tend to be highly similar (Hyde, 2005; Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Hyde & Linn, 2006) focus on findings that relate to the average differences between the sexes, which tend to be smaller than differences in high achieving or low achieving tails of distributions. On the other hand, difference maximizers focus on the tails of distributions, usually the high achieving tail, arguing that the highest achievers become our scientists, engineers, economists, physicians, and other professionals (e.g., Park, Lubinski, & Benbow, 2007; Wai, Lubinski, Benbow, & Steiger, 2010). Recall from [Chapter 2](#) that an important distinction was made between average differences and differences among the highest achievers (high ability tail) and lowest achievers (low ability tail). Most people score near the middle of the distribution—the mean or average—but often researchers are concerned with people who have particularly high or low ability. The difference between the average scores and tails of a distribution is important, so readers who are not certain what a “tail” of a distribution is should reread the relative sections in [Chapter 2](#), and carefully examine the various “bell-shaped” curves that are presented in that chapter.

Consider the comments made by Lawrence Summers in 2005, when he was president of Harvard University: “There are three broad hypotheses about the sources of the very substantial disparities that this conference’s papers document and have been documented before with respect to the presence of women in high-end scientific professions.” The three hypotheses that he outlined were (a) many women do not want to work the 80-hour weeks that are standard in high level careers, a topic that is addressed later in this book in the chapters on psychosocial hypotheses; (b) differences in how men and women are socialized and possible discrimination during the hiring process, which is also discussed in the later chapters that discuss psychosocial hypotheses; and (c) there are relatively few women with high-level aptitude to become the leaders in science and math. Thus, Summers used the relatively low ratio of

women to men in the high achieving tails of cognitive abilities as a main reason why women are underrepresented in “tenured positions in science and engineering at top universities and research institutions.”

An example from an area outside of cognition may help in demonstrating how important all of these factors are in understanding sex differences. Virtually all social scientists believe that males, on the average, are more aggressive than females. What does a conclusion like this really mean? No one believes that the meekest male is more aggressive than the brashest female. Everyone realizes that there must be overlap between the female and male distributions for aggression. As you will see in this example, the kind of conclusion we draw depends upon the portion of the distribution we study. Let’s consider the extremes of aggression, that is people who are exceptionally high and exceptionally low on aggression.

If we considered only the most aggressive individuals in society, we would have to conclude that there are huge sex differences with respect to aggression. The overwhelming majority of violent crimes (sadistic murders, rape, mutilation, serial killings, slasher crimes) are committed by males, and this is true in every society for which we have reliable data. For example, “between 82 and 94 per cent of all offenders in England and Wales found guilty of, or cautioned for, violence against the person, criminal damage, drug offences and robbery and burglary were male” (Office for National Statistics, British Crime Survey, 2007/2008, para. 3). Similarly, data from the United States show that “gender is the single best predictor of criminal behavior: men commit more crime and women commit less crimes” (American Law and Legal Information, 2010, para. 1). In the United States, 93.2% of prisoners are male (Harrison & Beck, 2003). Even though males commit most of the violent crimes in all societies, in fact, only a relatively small percentage of males are criminals. These data show how large sex differences in the extreme end of the distribution of violent behavior can have large effects on how we think about sex and crime.

Look carefully at [Figure 3.4](#). It shows the male:female ratio at the very highest tail (right-hand tail) of the distributions for the SAT-M and the ACT-M (American College Testing Service Math Test) and ACT-S (American College Testing Service Science Test). These data come from 1.6 million seventh grade students who took the SATs and ACT as part of the screening process to identify academically precocious youth. As shown in this figure, the ratios were approximately 13 males for every female in the early 1980s (Benbow & Stanley, 1980; 1983). These ratios decreased to approximately 7 males for every female in the late 1980s and then leveled off at between 3:1 and 4:1 since the early 1990s (Wai, Cacchio et al., 2010).

Because data from the SATs and other standardized tests are often used to document sex differences in cognition, it is important to keep in mind the fact that people who take college entrance examinations are a more select group than a sample of high school graduates, so the data from college entrance exams are drawn from high achieving students. The tails of these distributions

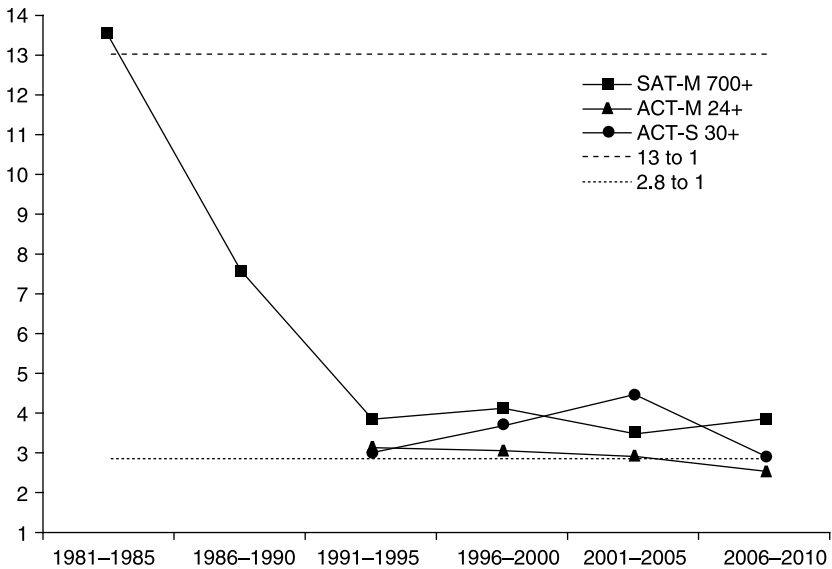


Figure 3.4 Ratio of males to females in right-hand (high scoring) tail of the SAT-M, ACT-M, and ACT-S from 1981 to 2010 for gifted youth. Notice that the proportion of males to females declined in the early 1990s and has stayed constant over the last two decades. Figure from Wai, Cacchio et al. (2010). Copyright © 2010, with permission from Elsevier.

are therefore data from high achieving students who are planning to attend college, and for these data, the sample is very high achievers who were identified as precocious youth. These data do not tell us why there are more males in the right-hand tail or whether the proportion of males to females will remain at between 3:1 and 4:1 or continue to decline as it did in the 1980s. They do, however, provide data about what is currently true about sex differences in the tails of these distributions for high achieving youth in the United States.

The high ability tails of standardized tests also show a clear advantage for girls on the SAT-Test of Written English (which was discontinued in 1994), the SAT-Writing sample (which was introduced in 2005), and the ACT-English test, which is a measure of verbal reasoning. The female advantage in writing is the most robust of these findings with the female to male ratio at 2.38:1 (in 2008; Wai, Cacchio et al., 2010).

Some researchers believe that data from standardized tests like the SATs are especially useful because they are based on very large numbers of test-takers and they can be used to show trends over time, such as the decline in the male to female ratios among the highest scorers from the 1980s to today. Others believe that data from college entrance exams should never be used because many more

females than males take the SATs, which means that the sample of females is “less select” than the sample of males, a fact that would be expected to decrease the mean scores for females, but should not affect the number of females scoring at the top. (The reasoning behind these predictions may need some additional thought. Imagine a group of 100 males and 100 females who are approximately the same in some ability. If the top 50 from each group took a standardized exam, we would expect approximately the same average score from each group, with the same proportion of females and males at the top and bottom range of the scores. Now imagine that the top 60 of the women and the top 50 of the men take the same test. Now we would expect a lower mean score for the women because the additional 10 women were lower in ability than the top 50 women. By reaching “deeper” into the proportion of women, more women with less ability are taking the test and they are bringing down the mean score for women.)

Data from the American College Testing (ACT) program support the general results from the SATs in the direction of sex differences, but not in the size of the differences. The ACT is a national testing program, which is also used in decisions about college admissions. To get around the problem that many more females take the SATs than males do, we can examine the data from the state of Illinois which requires all high school seniors to take the ACT. Data from 2009 show that 52% of test-takers from Illinois were female, so even with the requirement that all students take this test, more females take the ACT (ACT, 2009). There are four separate scores, with females scoring higher on English ($d = 0.10$) and reading ($d = 0.02$) and males scoring higher on mathematics ($d = 0.17$) and science ($d = 0.13$). Although results are in the same general direction as found with the SATs, the effect sizes are small. The ACT also reports the percentage of students who are ready for college-level work. Using the data from Illinois, these are 64% for males and 68% for females in English, 44% for males and 37% for females in mathematics, 48% for both males and females in reading, and 30% for males and 19% for females in science.

Variability

When we turn our attention to cognitive abilities, researchers regularly (but not always) report that males are more variable than females. In other words, there are more males than females at the very high end and at the very low end in many tests of cognitive abilities and, correspondingly there are fewer males than females in the range of average abilities (Deary, Irving, Der, & Bates, 2007; Hedges & Nowell, 1995; Hunt & Madhyastha, 2008; Willingham & Cole, 1997). Greater variability for males has been replicated with large samples in both the United States and United Kingdom (Lohman & Lakin, 2009). Thus, we find males to be overrepresented in both the top and bottom percentiles (e.g., more males in the top and bottom 10% on some tests) with smaller between-sex differences for those in the average range. It is important to understand that differences in average performance between males and

females tend to be smaller than differences at the extreme ends (either very low or very high performance). So, using the same data, we can conclude that females and males are very similar when we consider the average performance, and they are highly dissimilar when we consider performance at the high and low extremes.

Developmental Perspectives

Cognitive abilities change throughout the life span. We are born into the world with far fewer abilities than we have even a few years later, when we move from infancy into toddlerhood. We spend most of our lives as adults, a time when we use these abilities to earn a living, raise a family, and contribute to society. Of course, many people continue with these activities well into old age, but eventual cognitive slowing and decline is an inescapable fact of old age, even though there are some who can retain their cognitive abilities at high levels into old age. If we want to understand how males and females differ and are similar in their cognitive abilities, we will need to consider age as a critical variable because these abilities change over the life span.

Measurement Variables

How can we best measure amorphous concepts like intelligence or cognitive ability? This is a difficult question to answer. The way one chooses to measure these psychological constructs will also affect results. For example, Bridgeman and Morgan (1996) found that females tend to score higher on written measures than on multiple choice questions, with the reverse for males. In a recent analysis of whether different types of question formats affected responses by males or females, Kelly and Dennick (2009) looked at responses on examinations in 359 medical school courses. They found that males did better, on average, when questions were answered with a true-false-abstain format, but females did better with short answer questions. (The advantage for females on short answer questions was small compared to the much larger advantage males had on true-false-abstain questions.) These authors concluded that all assessments should be evaluated for the possibility of bias caused by the format used to assess knowledge.

The SATs were revised in 2006 so that they now consist of three tests, a critical reading portion (SAT-CR), a mathematics portion (SAT-M), and a writing portion (SAT-W). Taken together, these three tests are called the SAT-I to differentiate them from subject area tests, which are called SAT-II. The addition of a writing sample was expected to boost the scores of women, who tend to perform better on tests that require a written response. And it did. Women outperform men on the writing portion of the SAT by 13 points (male = 486, female = 499; College Board, 2009). But males perform slightly

better, on average, on the critical reading portion of the SAT, which requires a multiple choice response (male = 503, female = 498).

In 1996, the Department of Education arrived at a court-mediated agreement with the College Board concerning the Preliminary Scholastic Assessment Test (PSAT), a pre-college achievement test which is taken by more than 1.5 million students annually (College Board, 2009). The PSAT is used for determining semi-finalist status for the award of the prestigious National Merit Scholarships for college. In the past, a disproportionate number of these scholarships was awarded to males because they obtained higher average scores on the PSAT. As a result of the agreement, the PSAT now includes a writing component—one area in which girls usually excel. The addition of the writing component has resulted in a greater number of scholarship awards being won by females. The academic areas tested on the PSAT remain the same and, of course, the addition of a writing sample did not alter the average abilities of girls or boys; the only change is in the way their cognitive abilities were assessed. As expected, girls are now outscoring boys on the test of writing, a fact that balances the fact that boys outscore girls in the mathematics portion of these exams. As you can see from this example, measurement issues are critically important to how we understand sex differences in cognitive abilities and they also have important social consequences.

PERCEPTION

Better that a girl has beauty than brains because boys see better than they think.

—Author unknown (quoted in The Quote Garden, 2011)

All of our information about the world around us comes from our sensory systems. The cognitive or thinking process begins with the ability to sense changes in the environment and to make meaning out of the sensory stimuli constantly impinging on us. We no longer think that the infants' world is a bewildering array of random stimuli because it is now well known that newborns have innate capacities that they use to construct knowledge from sensory input. The first steps in the cognitive process are perception and attention. Sex differences in perception and attention are of particular interest because if there are sex differences at the earliest stages of information processing, this would provide a theoretical basis for positing sex-related differences in later stages. If we found early perceptual differences for boys and girls, these differences could create behavioral dispositions that vary as a function of sex. Differences in perception or attention would not mean that cognitive sex differences are inevitable or unalterable, only that they probably have an early physiological basis.

Audition, Olfaction, Vision, Taste, and Time Perception

Baker (1987) reviewed a variety of sex-related differences in perception and attention; and despite being over two decades old; it is still among the best overviews on this topic. She documented numerous sex differences in each of the sensory systems. The general conclusions have held up over intervening decades of research. In hearing, for example, females are better at detecting pure tones (tones of one frequency) during childhood and most of adulthood. Several studies have shown that adult females have more sensitive hearing for higher frequencies than males do and there have been several reports that school-aged girls have lower auditory thresholds than boys, which means that they can hear faint sounds better, but these differences are small and often are not statistically significant (reviewed in Al-Mana, Ceranic, Djahanbakhch, & Luxon, 2008). There are also sexually distinct patterns of hearing loss in middle age, with males beginning to lose the ability to detect high tones at about age 32 and females beginning to lose this ability at about age 37. A large-scale study of hearing in older adults in China found no differences in auditory function problems between ages 65 and 90 (Wang, Zheng, Kurosawa, & Inaba, 2009). A comparable large-scale study in the United States found greater hearing loss among men in their 70s and 80s than among women in this age range (Pratt, Kuller, Talbott, McHugh-Pemu, Buhari, & Xiaohui, 2009). Environmental causes for hearing loss in the sample of older adults in the United States can explain some, if not all, of the differences in hearing loss with aging—smoking, exposure to loud noises, and cardiovascular disease all contribute to hearing loss—and many of these causal factors are more prevalent among men than among women in the United States and most of the world.

In an extensive set of studies on sex differences in the auditory system, McFadden (1998; 2008) reported a wide array of sex differences in auditory perception ranging from binaural beats (a somewhat abstruse auditory phenomenon in which the brain produces a tone or “beat” when two tones of slightly different frequencies are presented separately to each ear), otoacoustic emissions (which are sounds generated by the auditory system that can be measured by sensitive microphones—females have stronger otoacoustic emissions than males). It is unlikely that differences of this sort can be attributed to sex-differentiated socialization practices. One reason for believing that sex differences in otoacoustic emissions are not caused by environmental experiences is that these differences are found in newborns (Berninger, 2007). Many of these sex-related differences in perceptual thresholds are detectable soon after birth, suggesting that they do not reflect learning, response biases, or postnatal environmental factors. For example, Reinisch and Sanders (1992) reported that newborn females are more sensitive to touch than newborn males. They found evidence of sex differences in the functional development of the

central nervous system as early as 3 months of age. These are important findings in our quest to understand sex differences in cognition because these early perceptual differences could create different behavioral dispositions for boys and girls. Slight behavioral predispositions could then be exaggerated, reduced, eliminated, or ignored, depending on the way cultures respond to male–female differences, although I note here that the size of the differences is small and there is so much overlap in the perceptual data for girls and boys that it is unlikely that they have any meaningful effect on behavior.

One sensory system where females have a clear advantage is the ability to detect faint smells. The term for this ability in the research literature is “olfactory threshold sensitivity.” Although women are more sensitive to some odorants and are better at identifying, discriminating (knowing that two very similar smells are indeed different), and remembering odors, the differences that are reported are usually quite small (Doty & Cameron, 2009). The female advantage in odor identification extends across the entire life span with females performing better at odor identification tasks from age 5 to 99 (Doty, Shaman, Applebaum, Giberson, Sikorsky, & Rosenberg, 1984). In a recent study of olfactory abilities across childhood, researchers found that the ability to detect odors and to identify them increased as children developed from ages 4 to 12, and girls performed better than boys (Monnery-Paris, Rouby, Nicklaus, & Issanchou, 2009). The researchers thought that one explanation for the superior ability of girls was that they had better verbal abilities than comparably aged boys and thus what appeared to be an advantage at an olfactory task really was a difference in verbal abilities—they were better able to label odors and remember the labels. This is exactly what they found. When they compared boys and girls who had the same verbal ability, the advantage that girls had shown in olfactory tasks disappeared. Thus, the difference was in the way females and males labeled different odors and their memory of the labels and not in the olfactory system. We cannot use this single study to conclude that males and females really have the same olfactory abilities because there is a large literature that found an advantage for girls, but this study does suggest that at least some of that advantage may be due to better verbal abilities among children aged 4 to 12.

Vision is a critically important sensory system for humans. In general, males under the age of 40 have better dynamic visual acuity (ability to detect small movements in the visual field) than females. Age-related loss of far vision occurs earlier for females (between ages 35 and 44) than for males (between ages 45 and 54). The question as to why there should be sex and age differences in dynamic visual acuity is more complex than it may seem at first. In a review paper on training in perceptual-cognitive skills, the authors discuss successful training programs that could, at least in part, explain these differences (Ward, Farrow, Harris, Williams, Eccles, & Ericsson, 2008). With deliberate and appropriate practice, people improve in these abilities. It may be that males, in general, who are more likely to play football, soccer, and other sports

and video games where the quick detection of visual motion is key to winning, may develop these skills through sports and other experiences. Several studies report sex difference in color vision, beyond what would be expected by the fact that many more males are color blind than females (McIntyre, 2002). For example, recent research on color vision found that when a random sample of adults were asked to match colors, the men and women used different ratios of red and green in their color matching (Pardo, Perez, & Suero, 2007). These results suggest that women and men may “see” colors somewhat differently.

In a review article on sex and aging effects in taste perception, Mojet (2004) reported that many studies reported sex differences, with males making more errors than females in recognizing the basic tastes of sour, sweet, salty, and bitter. In general when differences in taste perception are found, females are more sensitive to different tastes, but there are many researchers who did not find any sex differences. In her own studies, Mojet found that women perceive the intensity of aspartame as stronger than men did, with the reverse effects for quinine, so simple conclusions about one sex always being more sensitive to tastes are wrong. Other evidence shows that older men have higher taste thresholds than older women (i.e., they are less able to taste tiny concentrations of chemicals on their tongue). There are many possible reasons for these results, including the likelihood that men, in general, smoke more than women do and smoking impairs the ability to taste foods.

There are also sizable sex differences in temporal cognition, that is our knowledge of and judgments about the passage of time. Hancock (2011) conducted an extensive review of the research relating to sex differences in time perception and made sense out of a massive and inconsistent research literature that is well over 100 years old. He concludes that “there are consistent temporal processing differences between the sexes” (p. i). Interestingly, the nature of the difference in temporal judgments depends on how it is measured. A recent study of adult men and women between the ages of 20 and 69 found that women consistently underestimated short intervals (up to 20 seconds) and men consistently overestimated the same time intervals while using the production method of time estimation (Hancock & Rausch, 2010). In the production method, participants are asked to create a tone, often by pressing a lever that lasts as long as the estimated time. So with the production method, if participants were asked to estimate 2 seconds, they would depress a lever that would emit a tone and release it when they estimated that 2 seconds had passed. Results from the study in which women and men were asked to estimate 1-, 3-, 7-, and 20-second intervals are shown in [Figure 3.5](#).

It has been hypothesized that sex differences in time perception are caused by differences in body temperatures between females and males (Hancock, Vercruyssen, & Rodenburg, 1992). Females have higher resting body temperatures than males, which may affect the way each sex estimates time intervals. A recent study of sex differences in the ability to sense changes in temperature found at most a difference of 1 to 2 degrees (Fahrenheit) for children, so these

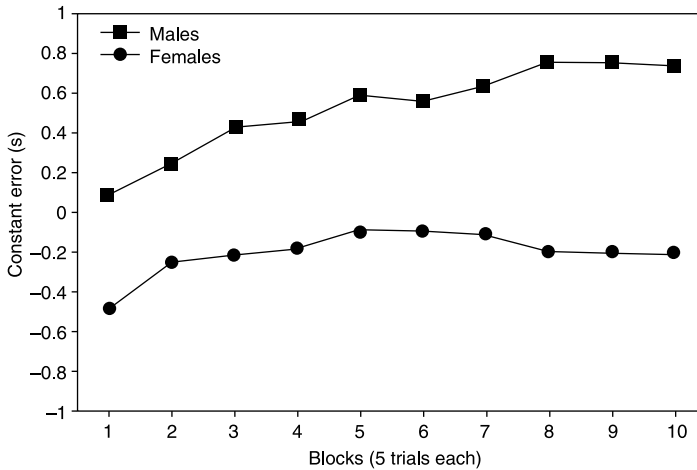


Figure 3.5 This figure shows the results of a time estimation task in which women and men were asked to press a button to estimate various time intervals (1, 3, 7 and 20 seconds). Over ten trials, men tended to overestimate the intervals with a positive level of constant error while women tended to underestimate the same intervals showing a negative level of constant error. Figure from Hancock and Rausch (2010). Copyright © 2010, with permission from Elsevier.

are very small differences (Blankenburg et al., 2010). In an extensive review of sex differences in time perception, the authors concluded that there are small, but reliable differences in the way women and men judge the passage of time (Block, Hancock, & Zakay, 2000), but these differences are moderated by many variables including age, the number of times (trials) each individual estimates the respective interval, and the way time judgments are assessed (Hancock, 2011).

Perceptual Motor Tasks

Sex differences favoring females are also reliably found on some speeded perceptual tests and some perceptual motor tasks. There are several tests that tap these abilities, each somewhat different in what it measures. Tests of perceptual speed and perceptual motor skills may require the rapid matching of stimuli, such as novel shapes, the “Finding A’s Task,” which requires scanning long columns of words and crossing those that contain the letter “A,” and copying simple forms from one line to another (Gouchie & Kimura, 1991). Another similar test of perceptual speed is digit-symbol coding. (It was a subset on the Wechsler Intelligence Tests, but was dropped from the Wechsler Tests in 2008 when the latest version of the WAIS—Wechsler Adult Intelligence Scale— was introduced.) As the name implies, the task for the

participant is to copy a row of symbols where each symbol corresponds to a number (e.g., $2 = \wedge$). In general, females copy more symbols correctly in a short period of time than males do (Burns & Nettlebeck, 2005; Weiss, Kemmler, Deisenhammer, Fleischhacker, & Delazer, 2003.). One test of perceptual speed involved a series of three outlined faces, one of which is different from the other two (Jäger & Althoff, 1994). The participant's task is to identify the "odd" face, which differs in one detail, such as missing an eye. There are no sex differences in this test (Hausmann, Schoofs, Rosenthal, & Jordan, 2009), which shows, once again, that although tests may be categorized as being similar (in this example all measures of perceptual speed), there are differences among the tests which could explain why sex differences are found on some tests of perceptual speed, but not others. These tasks usually require rapid, fine motor movements such as quickly marking a symbol on a paper, another area in which females excel. Jensen (1998) found a very large female advantage on tests of perceptual speed, with the effect size as large as $d = 0.86$ among 12th grade students. This is a very large difference between the boys and girls on these tests. (Effect sizes were discussed in [Chapter 2](#). Readers who are not sure what this term means should review the section on effect sizes so that they can understand what it means to say that an effect is large, medium, or small.)

Recall that general intelligence tests are written so that there are no overall differences in IQ scores for females or males, but there are differences in the subtests that make up the overall IQ. In a review of sex differences on the subscales of the WAIS-III (the newest version is the WAIS-IV, which was introduced in 2008), Longman, Saklofske, and Fung (2007) found a female advantage on the Processing Speed Index ($d = 0.31$), which is large enough to be meaningful, although like most of these indices, it is difficult to know what this difference would mean in everyday life.

Numerous studies have shown that females are usually superior at tasks that require fine motor manipulations. Kimura (1993) defined motor dexterity as "quick and effective use of the hands in the manipulation of small objects" (p. 1107). Nicholson and Kimura (1996) determined that women were faster than men when the task involved rapid repetitions of a sequence of movements. There is a large research literature on the topic of sex differences in motor tasks. Recent research shows that sex may be an important factor in motor performance and especially in motor learning. Most of the differences that are found in laboratory tasks are small, with little apparent application to everyday motor skills. These tests are sometimes labeled "clerical skills tests" and have been used to argue that females are naturally suited for clerical tasks like typing. I note here that fine motor skills are also needed in a variety of other professions such as brain surgery, dentistry, and the repair of small engines. One could just as easily use these experimental results to argue that females are naturally better suited for these other professions as well. Once again, I stress the distinction between research findings and the interpretation of these findings.

Findings of female superiority on fine motor tasks were questioned by Peters and Campagnaro (1996), who hypothesized that female superiority on fine motor tasks is an artifact of sex differences in finger size. To test this possibility, they had males and females perform a task that required subjects to rapidly move pegs in a peg board. They used both thick and thin pegs and had the subjects perform the task with and without tweezers as a way of controlling for finger size. They found that the female advantage on this task disappeared when the subjects had to use tweezers, a result that they interpreted as support for their hypothesis. As a follow-up to these studies, Rohr (2006) used a computer pointing task to investigate whether the distinction made by Peters (2005) would be supported with data from this task. Rohr found that although the women took longer than the men to make pointing movements, especially on more difficult tasks, they made fewer errors than the men did. Thus he concluded that “it is therefore important to consider gender-specific movement biases when interpreting performance differences and similarities between men and women” (p. 436). Thus, simple conclusions about which sex is better at fine movements will depend on whether speed or accuracy is assessed.

Numerous studies have found that women tend to be better at perceiving fine surface details by touch (e.g., Goldreich & Kanics, 2006). This finding holds up for blind as well as sighted participants, so it is not related to visual acuity. Women’s smaller finger size is responsible for their ability to feel fine spatial structures because small fingers have a great density of Merkel cells, which are the type of cells that give rise to the perception of textures (Peters, Hackman, & Goldreich, 2009). As the authors of this study explain, a man and a woman with fingers of equal size will experience the same tactile sensitivity.

On the other hand, motor tasks that involve throwing a projectile or otherwise aiming at a moving or stationary target show large advantages for males (Hall & Kimura, 1995; Watson & Kimura, 1991). This conclusion is based on studies that required throwing darts at a dart board or balls at a target and computer games that require subjects to “hit” a moving target on the screen, a task formally known as projectile interception. This is an important finding in the literature because of its implications for evolutionary theories. Recall from [Chapter 1](#) that males were the hunters in hunter-gatherer societies and would need these skills in order to kill prey and human and animal enemies. Of course, starting at an early age, males in western societies have more practice throwing balls and other objects, so it is also possible, perhaps likely, that these differences in throwing accuracy result from differential life experiences and are not a legacy from our evolutionary past.

Attention

The ability to attend to stimuli and to switch attention is both a precursor to and a consequence of the thinking process. There are huge sex discrepancies in attention disorders. Sex ratios for attention deficit disorder (a psychiatric

diagnostic category that often includes hyperactivity) range from 3:1 to 10:1 with the larger value corresponding to the proportion of males diagnosed (Biederman et al., 2002). One area of heated controversy concerns the question of whether infant boys and girls prefer to attend to (look at) different sorts of things, and the related question of whether there are sex differences early in life in the way infants understand the world. Spelke (2005) made a strong case against the idea that males have an intrinsic aptitude for mathematics and science. One of her main points was that males and females do not differ in what they attend to early in life. She cited numerous studies that support this contention. However, like almost every claim we will review pertaining to cognitive sex differences, there is also good evidence for the opposite conclusion. One reason why differences among female and male infants are so important is that they are unlikely to have been created by differential life experiences. In general, we tend to think of sex differences in infants as more likely caused by biological variables, but infant girls and boys are treated differently from birth, so we cannot know the influence of environmental variables even at very young ages.

Two related types of studies have emerged as critical in the dispute about differences early in life in female and male preferences. The first concerns whether infant girls and boys prefer different types of toys. Research has shown that sex differences in play start to emerge during the second year of life and are well established by age 3 (Ruble, Martin, & Berenbaum, 2006). Since children's sex-typed toy preferences (e.g., trucks for boys and dolls for girls) tend to resemble the activities of adult men and women, it seems logical that these toy preferences are caused by sex role socialization practices. To determine if sex-typed toy preferences occur early in infancy, Alexander, Wilcox, and Woods (2009) presented a doll and a truck to 5-month old girl and boy infants and recorded the number of times each infant looked at each toy. Looking time is a common measure of interest for infants. They found that boys looked at the truck and doll about equally; whereas, the girls looked at the doll much longer than the truck. These data are shown in [Figure 3.6](#). The authors concluded that their results show different patterns of attention to toys because girls and boys are attracted to different visual characteristics of the objects. They speculate that these innate preferences are likely to be enhanced by the continuous process of gender socialization. But, note an important point—the only difference was that girls were less likely to look at trucks than boys were. In theory at least, the baby dolls resemble humans and both the infant girls and boys looked equally long at the dolls (i.e., the difference was not statistically significant). The idea that these differences in toy preferences are biologically determined is discussed in more detail in [Chapter 4](#), where toy preferences for girls who were exposed to high levels of prenatal androgens are presented along with (possible) data showing sex-typed toy preferences in some nonhuman mammals.

The other type of finding regarding infant perception and cognition that is hotly disputed involves sex differences in an infant's ability to understand



Figure 3.6 Girl infants spent more time looking at dolls than at toy trucks; boy infants looked equally long at both dolls and trucks. Figure from Alexander, Wilcox, and Woods (2009). Reproduced with kind permission from Springer Science + Business Media.

complex events. There has been an explosion of research on infant cognition, and we have come to understand that infants have a much better understanding of the physical world than researchers ever imagined. One way infant cognition is studied is with “occlusion events.” As its name implies, an occlusion event occurs when something happens behind a screen, so it is occluded from view. In a standard set-up, an infant would be held on a parent’s lap with a small stage immediately in front of them. A ball would roll into view and pass behind a screen and then roll out a second or so later depending on how fast it was moving. Infants show that they expect the ball to roll out the other side of the screen by shifting their gaze to the other side of the screen. In a variation on this paradigm, infants watched while either a box or a ball was moved behind the screen. The screen was then removed and a ball was revealed. The ball would have been expected on those trials when a ball was moved behind the screen, but it would not be expected when a box was moved behind a screen. Infants showed their surprise at seeing a ball when they expected a box by looking longer at the surprising event. The researcher (Wilcox, 2007) found that male and female infants at 9.5 months did not look longer at what should have been the surprising event and therefore did not understand that if a box is moved behind a screen it should be there when the screen is removed; at 10.5 months, only the boy infants looked longer at the surprising event, and by 11.5 months both girl and boy infants registered their surprise with longer looking times. Of course, if this were the only study with this finding, it would need extensions and replications before it could be considered as good evidence for sex differences in early event processing. Other studies using other sorts of

events with infants have also reported that infant boys found some impossible results surprising at an earlier age than girls (e.g., Schweinle & Wilcox, 2004). But, in interpreting these results, keep in mind the possibility that early differences in how boys are played with and the toys they are given could be causing these sex differences.

Thus, sex differences are found in both perception and attention—the earliest stages of information processing—and in some fine and gross motor skills, although again I urge caution in interpreting these results. Even though there is considerable evidence for some sex differences in perception and attention, it is difficult to translate findings like differential touch sensitivity and hearing thresholds into predictions about cognitive performance. A conservative conclusion is that while there seem to be perceptual and attentional differences between females and males, we can only speculate about their influence on cognitive abilities, especially for males and females in the middle range of intellectual ability—the portion of the abilities distributions where most people (by definition) belong and where differences on most tasks are the smallest.

What Sex Differences in Perception Mean and How They Have Been Distorted

Put all of this information together, and it's clear that at birth, boys and girls do not differ dramatically in their perceptual abilities.

—Lise Eliot (2009, p. 61)

Reading through a long list of ways that males and females differ in perception can create a strong belief that women and men are living in separate worlds where sounds have different qualities, colors have different hues, and food has different tastes. But, in reality, all of the sex differences in perception are quite small, even for the most reliable ones such as differences in the ability to smell faint scents, remember odors, or estimate time intervals. Even more importantly, these differences have no effects for the vast majority of people in their day-to-day lives. Consider the finding that, on average, females can detect softer sounds than males can. First, it is critical that we remember that all of these differences are average differences, with wide individual differences. But even more importantly, these data do not support the idea that males and females have different perceptual worlds. Second, it is easy to lose sight of the many ways in which males and females do NOT differ in their perceptual abilities. Consider, for example, a study of sensitivity to and preference for the taste of calcium (Leshem, Katz-Levin, & Schulkin, 2003). Researchers believed that women would be sensitive to the taste of calcium and would prefer it relative to males because it is essential for growth and reproduction. These beliefs did not hold up empirically because there were no sex differences in either the preference for or the ability to detect low concentrations of calcium. This example with calcium is intended to show that there are

many more ways in which males and females are similar in perception than there are ways that they differ.

Unfortunately, the data on sex differences in perception have been misused to make statements like girls and boys need different lighting in their classrooms or that we need to talk to girls in a softer voice than we should use with boys or that girls need the temperatures in their classrooms 6 degrees warmer than boys do! These are the claims of some popular writers who advocate sex-segregated education (e.g., Sax, 2005). These statements show a misunderstanding of the perception literature. Perception thresholds are measures of the smallest amount of stimulation (e.g., intensity of a sound) that is needed for someone to just be able to perceive it. Girls are often able to perceive stimuli (a light or a sound) at lower levels of stimulation than boys. Differences in absolute thresholds (minimum amount of stimulation needed for detection) do not mean that boys and girls live in perceptually different worlds. If a constant level of sound is used in normal conversations both sexes will recognize that it is a normal talking voice, and it will NOT sound like shouting to girls or whispering to boys (which is what some advocates for single-sex education claim—see the National Association for Single Sex Public Education website for a misunderstanding of these data, <http://www.singlesexschools.org/research-learning.htm>). In addition, almost all studies of differences in perception thresholds have been conducted with adults and there is no reason to believe that they would be found in children because there are many developmental differences in perception between adults and children. What is even more important is that there is so much overlap in perceptual thresholds between males and females that any attempt to sort people on the basis of their perceptual thresholds would result in large percentages of both females and males in any grouping. Liberman (2006) calls claims that girls and boys need different sorts of educational experiences based on supposed differences in perception “neuroscience in the service of sexual stereotypes.” The claims that boys and girls need different types of education based on sex differences in perception are based on faulty reasoning and, in some cases, fiction. Bottom line: There are some differences in absolute thresholds and other perceptual measures for females and males (e.g., males are more likely to be color-blind; Rodriguez-Carmona, Sharpe, Harlow, & Barbur, 2008), but these differences do not mean that they see, hear, or process information differently or that girls and boys need different learning environments.

A COGNITIVE ABILITIES APPROACH

As stated earlier, there are no practical differences in the scores obtained by males and females on intelligence tests. Sex differences are, however, found in the subscores on intelligence tests. Intelligence tests are comprised of several subscores, each presumably reflecting a separate cognitive component that

also requires some general intelligence. One of the most widely used intelligence tests was devised by David Wechsler. The adult version is known as the Wechsler Adult Intelligence Scale (WAIS), and the children's version is the Wechsler Intelligence Scale for Children (WISC). The newest version of the WAIS is designated as "WAIS-IV." It yields four subscores of intelligence and an overall IQ score which does not show sex differences. The four subscores, which are usually called scales, include (a) a Verbal Comprehension Score comprised of scores on verbal subtests (e.g., similarities, vocabulary, information and comprehension); (b) a Working Memory Score (remembering digits, arithmetic, and letter–number sequences); (c) a Perceptual Reasoning Score (making block designs, matrix reasoning, visual puzzles, picture completion, figure weights); and (d) Processing Speed Score (symbols search, coding, cancellation) (Pearson Assessment, 2008).

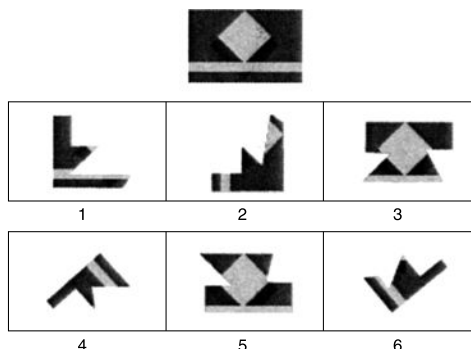
Sample items from three of the subtests that are new to the latest edition of the WAIS are shown in [Figure 3.7](#).

The older versions of the WAIS showed sex differences favoring females on a verbal subscale and sex differences favoring males on a performance subscale. The newest version now has four subscales and at the time of writing this version is so new that there are not many published studies comparing women and men on the new subscales. One study found small advantages favoring men at ages 16 to 64 on Verbal Comprehension, Perceptual Reasoning, and Working Memory and a small advantage (although it was larger than the others) favoring women for Processing Speed (Salthouse & Saklofske, 2010). The between-sex differences are so small that they are not likely to be meaningful.

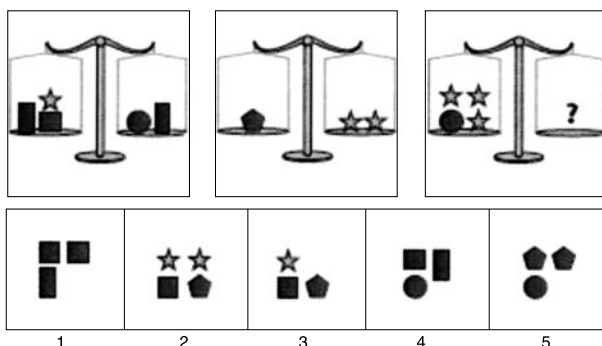
MEMORY

There is a long history of research showing a female superiority on many measures of memory. For example, a review article published in 1927 reported that "women are superior in all forms of memory" (Allen, 1927, p. 297). There are many varieties of memory, which means that cognitive psychologists do not think of memory as a unitary construct. Because there are many different types of memory, no single test can correspond to memory in general, and any conclusions about sex differences in memory will have to be modified to make it more specific to the task used to assess memory and what we believe to be true about the underlying cognitive processes. In an examination of sex differences in memory, Stumpf and Jackson (1994) analyzed a battery of tests that each assesses different aspects of memory. Their subjects were medical school applicants in Germany over a 9-year period. They found that women were substantially better on a battery of tests of memory than men (taken together, effect size, $d = 0.56$, over a half of a standard deviation). The authors of this study explained that memory is usually not studied in the context of sex

"Which 3 of these pieces go together to make this puzzle?"



"Which one of these goes here to balance the scale?"



"When I say go, draw a line through each *dark* square and *light* triangle."

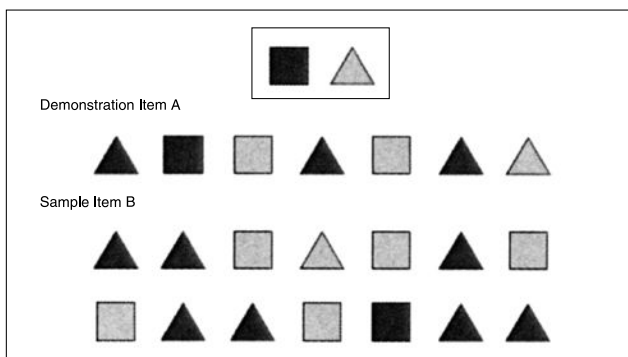


Figure 3.7 Sample items from three subscales on the WAIS-IV. Figure from <http://www.pearsonassessments.com/HAIWEB/Cultures/en-us/Productdetail.htm?Pid=015-8980-808&Mode=summary> Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV). Copyright © 2008 NCS Pearson, Inc. Reproduced with permission. All rights reserved. 'Wechsler Adult Intelligence Scale' and 'WAIS' are trademarks, in the US and /or other countries, of Pearson Education, Inc. or its affiliates(s).

differences because it is not a single concept (in the jargon of cognitive psychology, it is not a pure factor), a fact that makes it difficult to obtain consistent findings among studies. They believe that the size of the female advantage on memory tasks has been underestimated because the tasks that researchers use are unreliable and memory is a multidimensional construct. Stumpf and Jackson's use of a test battery corrects for some of these problems. In a later study, Stumpf and Eliot (1995) examined academically talented students in middle school and high school in the United States. In this study, they also found an advantage for females, this time on tests of visual memory. Recall from an earlier discussion in this chapter that females also have better memory than males for odors.

Episodic memory refers to memories for which someone can remember where and when they were when they learned the information that is being recalled—memories that include time and place of the information remembered. For example, if you can recall that women have better memory for odors than men do and that you just read about this, then this is an example of an episodic memory. But memory is one part of a complex cognitive system, which means that the likelihood that you remembered that women tend to have better memory for odors depends on what you were doing when you read that section. If you thought it was an odd or interesting fact, or if you related this finding to your personal experiences, it is more likely that you would remember this fact than if you are merely trying to finish reading this chapter as quickly as possible. Motives, prior knowledge, and interest are among the many variables that affect what is remembered. If you cannot recall where or when you learned something, then this sort of memory is called semantic memory. Semantic memory refers to our general knowledge of concepts, which is usually recalled without knowing when or where the information was learned. Across a wide variety of memory tasks, women have been found to have better episodic memories than men. Women are better at recognizing faces they recently viewed and names they recently heard or read (Herlitz & Kabir, 2006; Larsson, Lövdén, & Nilsson, 2003; Rehman & Herlitz, 2006.) The female superiority for remembering faces can be explained, at least in part, by the finding that females across all adult ages are better at recognizing facial emotions (Sasson, Pinkham, Richard, Hughett, Gur, & Gur, 2010). A large-scale study that was conducted on an internet news site, with over 7,000 participants, showed that the generally better ability to recognize emotions as expressed in faces is a likely explanation for women's better memory for faces. It seems that the faces may be more distinct when the viewer can infer the correct emotion and processing facial emotions makes the faces easier to recall.

There are a variety of different measures that show that female college students have better memory for speech that they have heard than male college students do (Ely & Ryan, 2008). Cognitive psychologists use the term "autobiographical memory" for the kind of memory that pertains to memory for events in one's own life. When college students were asked to recall speech

from their past—words that were spoken to them—women reported that they recalled many more instances of speech in their own personal lives (e.g., the words spoken when a parent told them the parents were divorcing). Women also reported younger ages for their earliest memories for feelings and emotions. In general, women recall more memories from childhood, and they report a younger age for their first memory than men do, with 7.78 years of age for women's earliest memory and 8.66 years of age for men's earliest memory (Davis, 1999). Of course, reports about one's memory are not the same as actual tests of memory, and it is possible that even though the women reported more early memories than the men this is a difference in how people report what they remember and not in memory per se.

As part of a national study in the United States with midlife adults, researchers found that women had better short-term memory than men (Pearman, 2009). Short-term memory was defined in this study as memory for events that are (approximately) up to 30 seconds old. The researchers measured short-term memory using a standard procedure that is part of the Wechsler Intelligence Scale that requires the participant to repeat lists of digits, first in the same order in which they are spoken (e.g., 5 9 4 3 0 7 7) and then to repeat them in the reverse order in which they were spoken (e.g., a participant would say 7 7 0 3 4 9 5 if she heard these digits in order starting with 5). In general, women recall more digits than men do using this research paradigm (a paradigm is a research procedure).

Jensen's (1998) extensive review of multiple tests showed that females scored higher on tests of short-term memory, with an effect size, d , between 0.20 and 0.30, depending on the nature of the test. These results have also been found with a sample of Chinese high school students where the girls had larger word spans (short-term memory for words), $d = 0.54$, and larger working memories, $d = 0.35$, than the boys (Huang, 1993). (Working memory refers to the processes used when both remembering something and processing information—such as remembering a list of numbers while also answering questions about an unrelated topic.)

Females also have better memories for spatial locations. This is the conclusion from studies by Eals and Silverman (1994), who believe these data reflect their evolutionary origins from hunter-gatherer societies in which females needed good memory for the location of plants in their role as the gatherers. This study was updated recently using participants from 40 different countries who logged into a BBC (British Broadcasting Corporation) website that collected data on sex-related spatial competencies (Silverman, Choi, & Peters, 2007). In 35 of the 40 countries, women scored higher than men on a test of their ability to remember where an object was located. In a meta-analysis, which is a statistical review of many different studies, Voyer, Postma, Brake, and Imperato-McGinley (2007) analyzed the results from 36 different studies on memory for objects (remembering, for example, if participants saw a shoe or a house) and memory for object location (where an object was shown,

for example, in the upper left corner of a photo). Women showed better memory for objects and object location (with few exceptions, such as memory for uncommon objects) from age 13 through adulthood. Thus, the female advantage in memory is found across a variety of task and ages.

VERBAL ABILITIES

Women appeared to perform relatively well with a format that requires written responses.

—Bruce Bridgeman and Gordon McHale (1996, p. 16)

Evidence from a variety of sources supports the finding that, on the average, females have better verbal abilities than males, but the advantage is likely to be small and depends on the type of verbal ability that is measured. Like the other cognitive abilities, “verbal abilities” is not a unitary concept. The term applies to all components of language usage: word fluency, which is the ability to generate words (both in isolation and in a meaningful context), grammar, spelling, reading, writing, verbal analogies, vocabulary, and oral comprehension. There is also strong neurological evidence that separate brain subsystems are involved in generating language, comprehending language, using grammatical rules, and in producing and decoding speech sounds (Gazzaniga, Ivry, & Mangun, 1998). The size and reliability of the sex difference depend on which of these aspects of language usage is being assessed. Consider the various verbal questions that are shown in [Figure 3.8](#). As you can see, they tap related but somewhat different abilities. Much of the confusion in the literature comes from the failure to distinguish among language tasks, some of which show no sex differences while others show large sex differences. When sex differences in verbal abilities are found, they virtually always show better performance by females.

According to a study released in 2010, there is “good news for girls and bad news for boys . . . overall male students in every state where data are available lag behind females in reading” (Robelen, 2010). Rivers and Barnett (2010) remind us that we should not “read too much into boys’ verbal scores” because a closer look at the data shows a pattern of results that provides a context for understanding these and similar data on differences between boys and girls. When the data are analyzed separately by race and social class, the data show a different picture. White and Asian boys in suburban schools are not behind in reading, and they do not drop out of school at high rates. Black and Hispanic boys, especially those in urban schools, do more poorly, but so do Black and Hispanic girls in poor-performing schools. Among White boys, those in rural areas and those in poverty also are behind in reading. Thus, what appears to be a simple sex difference is really more complex. In general, boys’ reading achievement has been improving, but at the same time, girls are improving at

TESTS OF VERBAL ABILITIES

1. Name as many words as you can that start with the letter "k."

2. Select the word that is most nearly the same in meaning:

VIVACIOUS A) HONEST
 B) MEDIOCRE
 C) LIVELY
 D) BRAT

3. IGLOO: INDIAN :: TEPEE:

A) ICE B) CANVAS C) ESKIMO D) HOME

4. Answer the questions based on the information provided in this passage.

The literature with regard to sex differences in verbal abilities has been mixed with some researchers reporting large differences and others reporting no statistically significant differences. It seems that the controversy can be resolved by looking at the types of verbal tasks in which differences are found and determining how they differ from tasks in which differences are not found. It may be that tasks like solving verbal analogies are more similar to mathematical problem solving than to some of the other verbal tasks.

a) What is the "controversy" that is referred to in the second sentence?

b) Why does the author suggest that verbal analogies are similar to mathematical problems?

5. Which is correct?

a) Give the money to Bob and I.

b) Give the money to Bob and me.

6. Recall the words in a word list (e.g., book, sign, worry, sleep, justice, railroad, money, diamond, child, hospital, movie, lamp) or recall the objects in a room you were in recently.

7. Write a story about growing up as an immigrant in a foreign country.

Figure 3.8 Tests of verbal ability. Each of these tests may be tapping a different type of verbal ability.

an even faster rate. Although there is much to be concerned about in these data, the simple idea that boys are failing at reading or any other verbal skill is plain wrong. This conclusion is supported by a meta-analysis conducted by Hyde (2005) in which she concluded that the female superiority in verbal abilities is so slight that it is meaningless.

What about sex differences at the highest ability end of the distribution for verbal skills? The answer to this question was presented earlier in this chapter where sex differences in tails of distributions were discussed. Wai, Cacchio et al. (2010) answered this question using data from seventh graders who took college entrance tests as part of the screening process for a program for academically precocious youth. They examined data from the SAT-W, which is a writing test that was introduced in 2005, the SAT-V and SAT-Test of Standard Written English. For most years, the ratio of males to females was approximately equal among the highest scorers on the SAT-V. Wai et al. concluded that the female advantage in writing is the most robust, peaking at 2.38 females to every male among test-takers who scored above 700.

Scores of females and males on the ACT-English test are shown in [Figure 3.9](#). On average, females outperform males on this college admissions test.

There are numerous indicators of sex differences in verbal abilities when we consider the low end of the verbal abilities distribution. Simply stated, “the overwhelming majority of children in special education today are boys” (Meyerhoff, 2008, para. 2). Boys are classified as learning disabled at approximately twice the rate of girls and as emotionally disturbed at 4 times the rate of girls, two factors that are probably related (Henning-Stout & Close-Conoley, 1992).

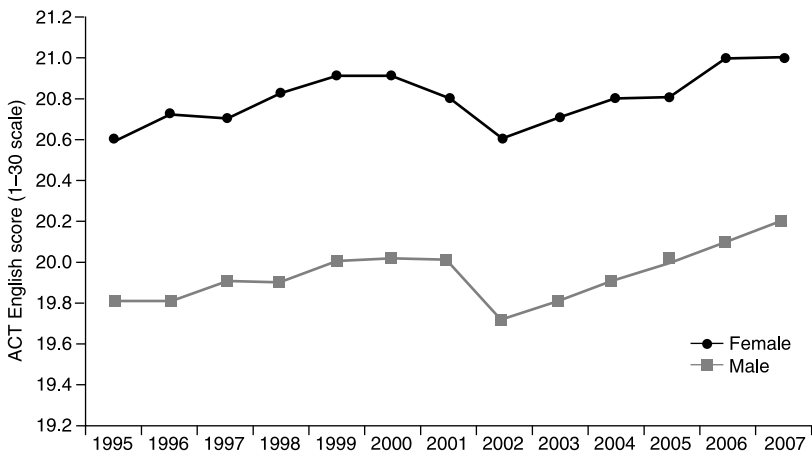


Figure 3.9 Mean scores for males and females on the ACT-English test, which is commonly used for college admissions decisions. Unpublished data provided by the ACT Statistical Research Department. Reprinted with permission of ACT, Inc.

Stuttering, a disability in the production of fluent speech, is overwhelmingly a male problem. Estimates about the percentage of children and adults who stutter vary, probably because of differences in who is sampled and how stuttering is defined. For example, one researcher reported that stuttering affects more than 15% of children between 4 and 6 years of age, but this drops to between 1% and 2% for adults (Gordon, 2002). According to the National Institute on Deafness and Other Communication Disorders (NIDCD, 2010), approximately 5% of all children stutter at some time in their childhood. Many sources on stuttering agree that there are 3 to 4 times more male stutterers than female stutterers (NIDCD, 2010). Other experts have estimated sex ratios in stuttering to be as high as 10:1 (Woodruff-Starkweather & Givens-Ackerman, 1997). Thus, the exact ratio of males to females depends on how stuttering is defined, but all measures clearly show that stuttering is overwhelmingly a male disorder.

There are also sex differences in other measures of speech disability. For example, men are more likely to exhibit aphasia (impairment in producing oral speech) when they have a stroke than women are (Di Carlo, Lamassa, Baldereschi, Pracucci, Basile, & Inzitari, 2003). A stroke occurs when a blood vessel ruptures and results in a loss of oxygen to the brain. In general, women experience their first stroke at an older age than men do, so any findings about sex differences in strokes is also confounded by age. Although earlier research showed that women were better able to regain language following strokes and brain surgery (Witelson, 1976), this finding has not held up in more recent research (Cloutman, Newhart, Davis, Heidler-Gary, & Hills, 2009), so any conclusion about the recovery of speech following a stroke will have to await more research.

Boys are much more likely to have reading disabilities than are girls (Rutter et al., 2004). Dyslexia, a severe reading disability found in individuals whose other cognitive abilities are within normal ranges, is also predominantly a male problem, with most samples showing at least twice the incidence of reading disorders for boys as compared to girls. These conclusions are from research conducted at four different sites in New Zealand and the United Kingdom. Although approximately 2% of the school population is dyslexic, mild dyslexia is 5 times more likely to occur in males than in females, and severe dyslexia is 10 times more likely to appear in males than in females (Sutaria, 1985). The conclusion that boys are, in general, less skilled in reading is supported by international data from the Programme for International Student Assessment (PISA; Organisation for Economic Co-operation and Development, 2009, p. 79). In a cross-national study of 30 countries, 3.7% of females and 0.8% of males are in the category designated as “top performers in reading,” so girls are both more likely to be among the best in reading and less likely to have a reading disability.

The female advantage in verbal abilities can be seen in creative writing. Kaufman, Niu, Sexton, and Cole (2010) found that women’s poems were judged as more creative than men’s poems, even when the sex of the writer is unknown. These creativity researchers reviewed several other studies with similar conclusions: women write more creative poems than men do, but scores

on general creativity tests show few differences (most of which favor females), suggesting that the advantage that females have in creativity is most probably limited to verbal tasks (Bauer & Kaufman, 2008).

The research evidence from a variety of sources favors female superiority on verbal tasks including reading and speaking and is largest in the high and low ends of the distribution. Despite the finding that females score higher on at least some tests of verbal ability, the overwhelming majority of critically acclaimed writers are male. Other careers and prestigious professions that require advanced verbal abilities, careers like lawyer, politician, and journalist, are also predominantly male. Adelman (1991) noted this disparity in a report for the U.S. Department of Education, called the “paradox of achievement,” and laments the economic loss to the United States created by the underdevelopment of women’s intellectual potential. In his own words:

The paradox of this story—that women’s educational achievements were superior to those of men, but that their rewards in the labor market were thin by comparison—is set in the context of national economic development. (p. v)

There are several possible reasons for the discrepancy for women between their abilities and their achievement. It is possible that women are not using their talents as frequently as men, or the tests are not measuring high-level creative ability, or differential criteria are being used to judge women’s and men’s writing. It is interesting to note that several outstanding women writers such as Dickinson and the Brontes were single women with other means of support. If ability is only a small part of eminence, then the lack of eminent female writers is not surprising.

Age Trends in Verbal Abilities

Sex differences in some verbal abilities appear early in life. According to Cole and Cole (2001), children learn to use 200 to 300 words by age 2. Between 16 months and 30 months of age, girls lead boys in the number of words they can say by about one month of development (Fenson, Dale, Reznick, Bates, Thai, & Pethick, 1994). Another study provided a somewhat higher estimate of girls’ early vocabulary development, with 2-year-old girls using an average of 275 words, whereas boys use an average of 197 words (Lutchmaya, Baron-Cohen, & Raggatt, 2002). Girls also show better language skills in preschool (e.g., Blair, Granger, & Razzam, 2005). Based on a review of 24 large data sets (including several large representative samples of U.S. students, working adults, and military personnel), Willingham and Cole (1997) concluded that differences are small in the elementary school grades, with only writing, language use, and reading favoring females at fourth grade, $d > 0.2$. In the United States, by the end of high school, the largest differences, again favoring females, are found for writing (d between 0.5 and 0.6) and language usage (d between 0.4 and 0.5).

Another report on writing proficiency for children in Grades 4, 8, and 11 in 1984, 1988, and 1990 showed that girls were better writers in each of the nine comparison groups (U.S. Department of Education, 1997). More recently, the 2007 Nation's Report Card reported that females are 20 points ahead of males in writing in eighth grade ($d = 0.4$) and 18 points ahead in 12th grade ($d = 0.36$; National Assessment of Educational Progress, 2008). After a comprehensive review of the literature on writing skills, Hedges and Nowell (1995) concluded: "The large sex differences in writing . . . are alarming. These data imply that males are, on average, at a rather profound disadvantage in the performance of this basic skill" (p. 45). This conclusion is supported by data from the U.S. Department of Education (2000) that show that girls in their senior year of high school are approximately 36 months ahead of boys in writing skills.

Skillful writing is a generative activity that includes good organization of ideas, grammatically correct constructions, and accurate use of words. The conclusion that females excel in writing is bolstered by data released by the U.S. Department of Education on writing proficiency tests given at Grades 4, 8, and 11 in 1984, 1988, 1990, and most recently in 2007. The data from 2007 are graphically presented in Figure 3.10. The graph shows that girls in eighth and twelfth grades are writing better than same-age boys.

In a detailed investigation of language development among children aged 2½ to 4 years, Horgan (1975) examined the mean length of utterances (MLU, the average number of words strung together in a single utterance) for girls and boys.

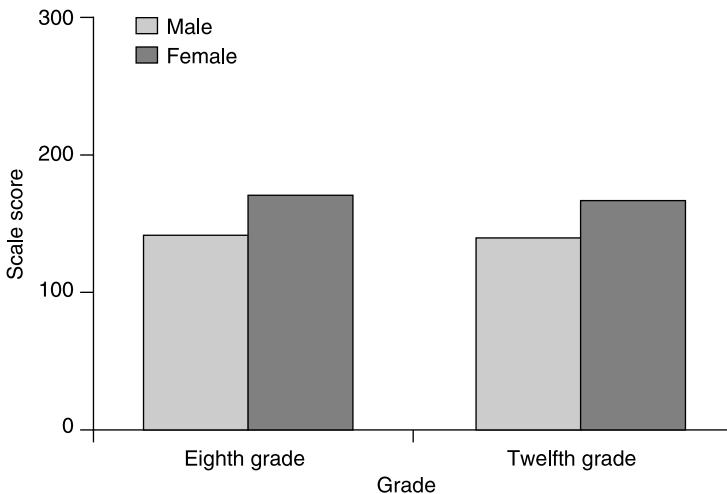
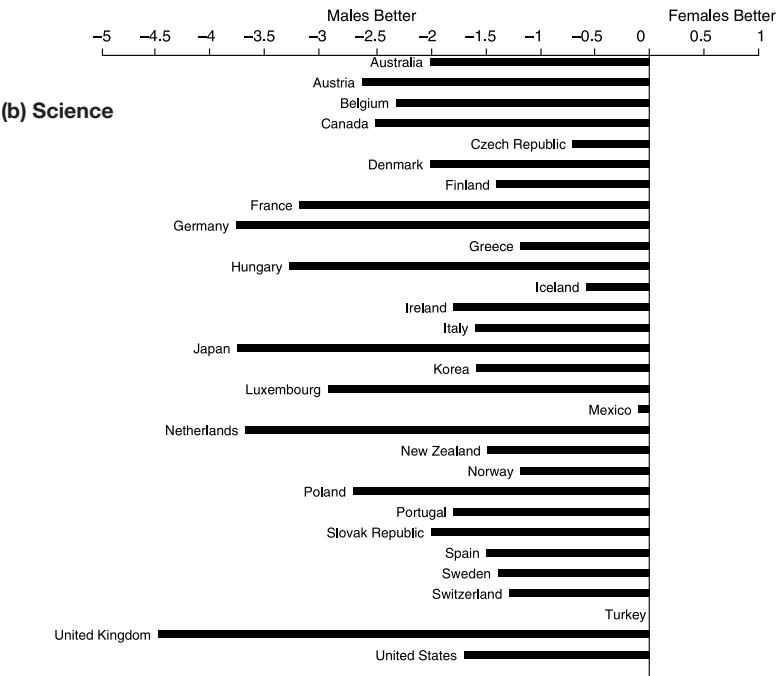
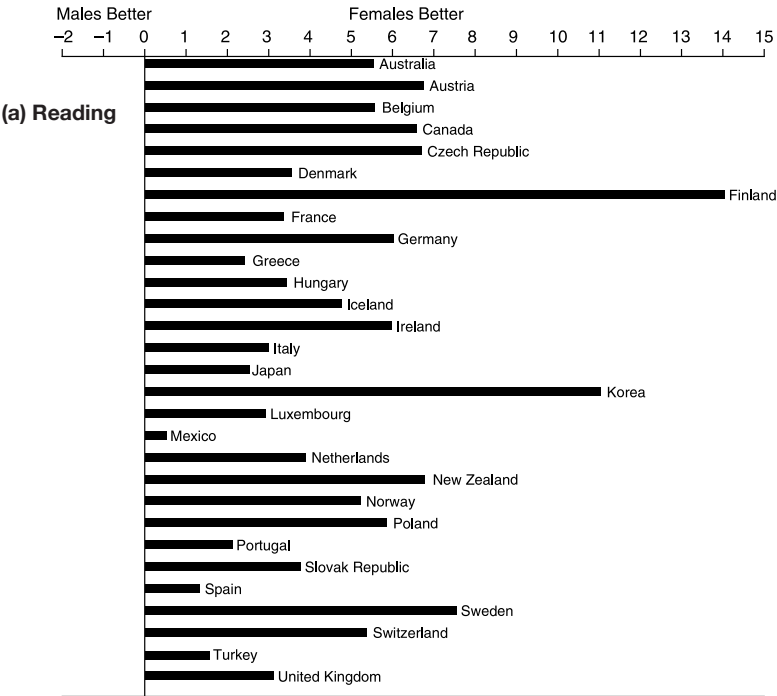


Figure 3.10 Writing proficiency scores for males and females in eighth and twelfth grade. These data correspond to effect sizes of $d = 0.40$ for eighth grade and $d = 0.36$ for twelfth grade. Data from U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics (2007a).

She argued that MLU is a good indicator of linguistic maturity for preschool children who are learning their first language. Horgan reported that prior to MLUs of four words, boys and girls perform equally well; however, sex differences favoring girls occur beyond MLUs of four words (i.e., girls use longer utterances at younger ages than boys). Horgan also analyzed other indicators of linguistic maturity including: use of the passive voice (e.g., The lamp was broken); truncated passive (e.g., The window's broken.); and use of participles (verbs used as adjectives—e.g., The moving truck crashed). Girls spontaneously generated all of these advanced linguistic forms at an earlier age than males; furthermore, they made fewer errors in language usage overall. Horgan concluded: "Girls produce longer utterances at younger ages, they produce more varied constructions, and they make fewer errors" (p. 48). In a more recent study with Swedish children, Lundberg (2009) studied phonological awareness in 1,100 6-year-old children in preschool. Phonological awareness is knowledge about the relationship between letters and their sounds. If children do not understand the relationship between letters and their sounds, they are at great risk for reading failure. Lundberg found that 19% of the boys, but only 7% of the girls, were among the children with the poorest performance. By contrast, the group with the highest level of performance contained only 14% of the boys, but 29% of the girls. After training the children in phonological awareness for 8 months, there were very few children with low scores, but the highest performing group was 73% of the girls and 47% of the boys. In general, the majority of the evidence tends to support the idea that young girls are more verbally precocious than young boys. Of course, it is important to remember that these are group averages, and almost half of all boys reached the highest levels of phonological awareness after 8 months of training.

Female superiority on verbal tasks may seem reminiscent of the stereotype that females talk more than males, but it is the quality of the speech produced and the ability to comprehend or decode language that is being assessed, not merely the quantity. Some readers may be thinking about the well-known finding that females talk about 3 times as much as males do. This statistic has been repeated on television (CBS and CNN), National Public Radio, *Newsweek*, in *The New York Times*, and *The Washington Post* (Mehl, Vazire, Ramirez-Esparza, Slatcher, & Pennebaker, 2007). The problem with this common knowledge is that it is wrong. To test the difference in words spoken per day, Mehl and his colleagues fitted men and women with recording devices that were automatically activated when there are speech sounds. The real numbers are that women speak an average of 16,215 words a day compared to 15,669 words a day for men. This difference was statistically significantly different, but so small ($d = 0.07$) that it is not meaningful!

The general superiority of girls in reading can be seen internationally in [Figure 3.11](#), which shows the difference in the percentage of top performers between females and males in international tests. The differences in the percentages of top performers in science and mathematics are shown in [Figures 3.11b](#) and [3.11c](#).



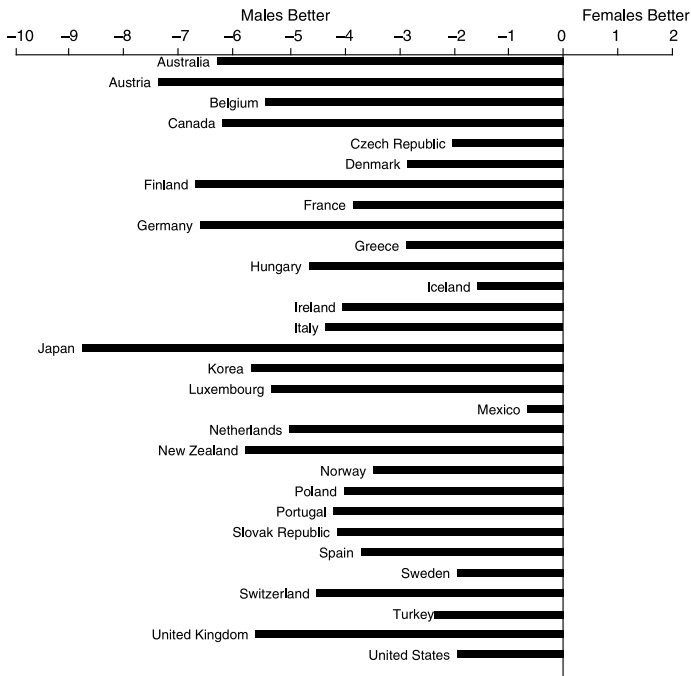
(c) Mathematics

Figure 3.11 Bar chart showing the difference in the percentages of top performers between girls and boys. Data from *Education at a Glance 2009*, Organisation for Economic Co-operation and Development (2009). Data are from Table A4.1b. Note that negative numbers indicate a higher percentage for males and positive numbers indicate a higher percentage for females.

In an extensive meta-analytic review of the literature on sex differences in verbal ability, Hyde and Linn (1988) divided experiments based on the age of the subjects and type of verbal ability assessed—all tests, vocabulary tests, and tests of reading comprehension. Differences were found in the “all tests” category for children 5 years and younger ($d = 0.13$) and for adults over the age of 26 ($d = 0.20$), both favoring females. There were no notable differences as a function of sex for ages 6 through 25. The developmental pattern of vocabulary proficiency is difficult to comprehend. Hyde and Linn reported a male advantage in the 6- to 10-year-old age range ($d = -0.26$) and a female advantage in the 19- to 25-year-old age range ($d = 0.23$), with essentially no differences in the other age categories. The largest differences were in reading comprehension for children 5 years of age and younger, with females reading more proficiently than males ($d = 0.31$). Hyde and Linn’s meta-analytic review is now well over 20 years old and may have underestimated the size of the female advantage on a variety of verbal tasks, at least when compared with more

recent studies, probably because of the types of verbal ability tests they reviewed.

In a 10-year study, De Frias, Nilsson, and Herlitz (2006) found that across age groups ranging in age from 35 to 80 years, the female advantage in episodic memory (remembering names, words, and activities, recognizing faces), vocabulary, and fluency tasks (naming words that begin with a particular letter such as “M” and naming words by category, such as “professions”) remained constant over the 10-year period of their study. These researchers also found that the size of the sex difference in these tests did not change with age. The authors concluded that “There was stability of sex differences across five age groups and over a 10-year period” (p. 574). These are tests of verbal memory, which seem to support the conclusions that on average, females excel at some memory tasks and some verbal tasks.

Although it seems that there is little change over a 10-year period in the size of sex differences, a different picture emerges when data are collected from a very large sample of adults that range in age from 20 to 60 years. The BBC sponsored an internet study of sex differences, which resulted in many different published studies of cognitive sex differences (Lippa, 2007). Almost half a million people took a variety of cognitive tests online and responded to demographic questions. The treasure trove of data has provided a unique opportunity to answer many questions about cognitive sex differences and results from this study appear in several places in this book. In one set of analyses, researchers examined sex differences on memory for the location of an object and category fluency (e.g., naming as many members of some category, such as animals, as possible in one minute). In one of these studies, the researchers (Maylor, Reimers, Choi, Collaer, Peters, & Silverman, 2007) found the usual advantage for females with these tasks ($d = 0.33$ for memory for location and $d = 0.18$ for fluency), but when they looked across the age range they found two important results: (a) performance declined with age; and (b) the decline was greater for males. As you will read in the next section, men also showed greater decline with age on other types of tasks.

VISUOSPATIAL ABILITIES

Too many jokes to recount here are made about the spatial skills of women versus men. While once good-humored, they now take on a social significance that becomes lost in current social values.

—Michael Gazzaniga, Richard B. Ivry, and George R. Mangun
(1998, p. 507)

The term “visuospatial abilities” may not convey much meaning to people who are not cognitive psychologists. In fact, it is not an easy term to define because

it is not a unitary concept. Linn and Petersen (1985) provided this definition: “*Spatial ability* generally refers to skill in representing transforming, generating, and recalling symbolic, nonlinguistic information” (p. 1482). Generally, it refers to the ability to imagine what an irregular figure would look like if it were rotated in space or the ability to discern the relationship among shapes and objects. The ability to utilize spatial relationships is an important aspect of human thought. Visuospatial skills (spatial skills that are visual in nature) are used extensively in engineering, architecture, chemistry, the building trades, and air crew selection (Lohman, 1988). After reviewing the literature on visuospatial ability, Cooper and Mumow (1985) concluded, “The spatial aptitude literature is quite clear in showing that a broadly defined spatial factor exists independent of verbal and quantitative factors and that this spatial factor is more effective than other measures of intelligence in predicting success in certain academic and industrial areas” (p. 71).

Five Categories of Visuospatial Abilities

In 1985, Linn and Peterson used factor analysis, a data analysis technique that finds commonalities in the data, on a number of tests of visuospatial abilities. The results clustered the tests into three main categories—spatial perception, mental rotation, and spatial visualization. Although numerous new tests of visuospatial ability have been used since then, and hundreds of different tests have been identified as measures of visuospatial abilities, the three categories that they identified plus two others—one that involves movement through space and another that involves the generation and maintenance of visual images—are a good organizing framework for understanding the literature in this area. If you are wondering what “generation and maintenance of visual images” means, try this demonstration: Think about a lower case letter “b.” Is the round portion of the “b” to the left or to the right of the vertical line that forms the other portion of the letter? In order to answer this question, you had to generate a visual image of a lower case “b” and then maintain that image in memory while answering questions about its appearance. This is an example of generating and maintaining a visual image.

I have included memory for visuospatial information on this list of five categories of visuospatial tasks, even though it was also discussed in the section on sex differences in memory. All of these tasks involve several types of memory, so they fit into more than one cognitive category. It seems that there are at least five qualitatively different types of visuospatial ability:

1. *Spatial perception*, requires subjects to locate the horizontal or the vertical in a stationary display, while ignoring distracting information. Examples are the Rod and Frame Test, which requires subjects to position a rod within a tilted frame so that it is either vertical or horizontal, and the Piaget

Water-Level Test, which requires subjects to draw in the water level of a tilted glass that is half filled with water. An example of the Water-Level Test is shown in [Figure 3.12](#).

One test that is sensitive to sex differences is the “Water-Level Test” originally devised by Piaget and Inhelder (1956). In one version of this test, the subject is shown a bottle partially filled with water and is told to notice the way the water fills the bottle. The subject is then asked to predict where the water will be when the bottle is tipped. Piaget and Inhelder believed that the relevant knowledge about the horizontal would be attained at an average age of 10 years. The Water-Level Test as originally conceptualized by the developmental psychologist Piaget was never intended to test anything about water per se. It was meant to be a task of spatial concepts—in this case the ability to use a Cartesian coordinate system to represent space—but increasingly contemporary researchers discuss it as a test about the fact that the surface of water remains horizontal despite the tilt of its container, thus the meaning of this test has drifted since it was originally devised by Piaget. It seems that girls demonstrate this principle at a later age than boys. In fact, it has been estimated that 40% of college women don’t know the principle that the water level remains horizontal. This is a surprising result that has been replicated many times (Wittig & Allen, 1984). Robert and Chaperon (1989), for example, reported that 32% of college women and 15% of college men failed the

Figure A shows a bottle with some water in it.

In Figure B the bottle has been tilted.

Draw a line to show how the water line would look.

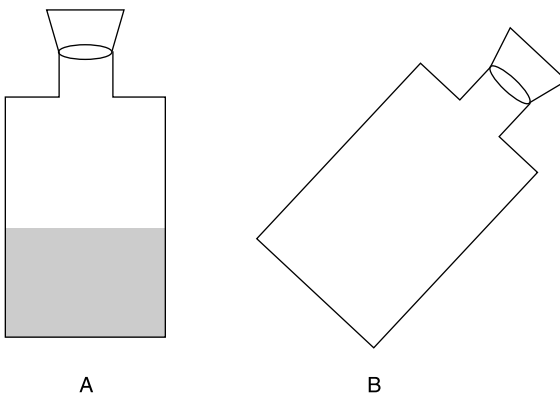


Figure 3.12 An example of the Water-Level Test. The task is to draw in the top of the water level in Bottle B, assuming that it is Bottle A tilted on its side.

Water-Level Test. Sex differences in the Water-Level Test have been confirmed internationally, for example, with a sample from Bombay, India (De Lisi, Parameswaran, & McGillicuddy-De Lisi, 1989). Vasta and Liben (1996) reported effects sizes that range between $d = 0.44$ and $d = 0.66$. It is difficult to understand why this should be such a formidable task for college women.

Results from the Water-Level Test are strange. Why should women (in many samples college women were used as participants) perform less well on a test of whether water remains horizontal in a tilted glass? As discussed in [Chapter 6](#), at least part of the sex differences we find with spatial tasks can be attributed to differential learning experiences, with boys typically engaging in more spatial activities. Sex differences in the Water-Level Test are not amenable to this sort of explanation as no one believes that boys have more experiences than girls with glasses of water. In one study, Hecht and Proffitt (1995) hypothesized that experience with liquid surfaces would be associated with poorer performance on the Water-Level Test because people who work frequently with liquids in containers may have adopted a perspective that was relative to the tilt of the container—in other words they paid attention to the orientation of the container and not the level of the water surface. In a test of the hypothesis that more experience would lead to poorer performance on the Water-Level Test, Vasta, Rosenberg, Knott, and Gaze (1997) found the reverse results: subjects with more experience performed better than those with less experience. Thus, the poorer performance of females on this test remains unexplained.

Kalichman (1989) investigated the possibility that the results reflect some idiosyncrasy of the test, rather than sex differences in either the knowledge that water remains horizontal or the ability to draw an approximately horizontal line. Kalichman devised a more “ecologically valid” (i.e., more like the real world) test in which the tilted glass was held in a human hand. An example of his stimuli is shown in [Figure 3.13](#).

Kalichman found that significantly fewer college women than college men draw an approximately horizontal line to indicate the water level in both the standard test format and in the human context format. He concluded that “sex differences on the water-level task remain robust regardless of task context” (p. 138). The Water-Level Test was used in a study of 1,704 participants ranging in age from 4 to 95 years (Tran & Formann, 2008). They used depictions of eight round bottles tilted at nine different degrees. The authors found that performance was best for adults between the ages of 16 and 60, with considerably lower performance at younger and old ages. They also reported a sex difference, which they claim was significant from adulthood into old age, but it was significant at young ages only for certain degrees of tilt. But a careful look at their data suggests that there was a floor effect at the younger ages, meaning that both girls and boys were performing so poorly at these ages that it would not be possible to tell if there was a sex difference. (See [Chapter 2](#) for a discussion of floor and ceiling effects and how they can mislead researchers into



Figure 3.13 The Water-Level Test embedded in an ecologically valid (i.e., real-world) context. The glass is half-filled with water. Draw a horizontal line across the glass to indicate the top of the water line. Reprinted from Kalichman (1989) with permission from the author and Taylor & Francis.

concluding that there are no differences.) Many psychologists have studied sex differences on the Water-Level Test, perhaps because it is surprising. Correct performance on this task requires that participants understand that the surface level of water remains horizontal regardless of the tilt of the glass. As Vasta and Liben (1996) concluded in their review of this task, the puzzle is far from solved.

2. *Mental rotation*, includes the ability to imagine how objects will appear when they are rotated in 2- or 3-dimensional space. There are timed and untimed versions of these tests. Several researchers believe that mental rotation is a measure of a general spatial reasoning ability (Casey, Nuttall, Pezaris, & Benbow, 1995). In a recent study of college students at a highly selective school for science and engineering, the sex difference on a test of mental rotation was close to $d = 0.60$ (Miller, Halpern, & Saeta, 2010). A classic example of mental rotation is shown in [Figure 3.14](#). The task is to determine which (if any) of the figures on the right can be rotated in space so that they are the same as the figure on the left.

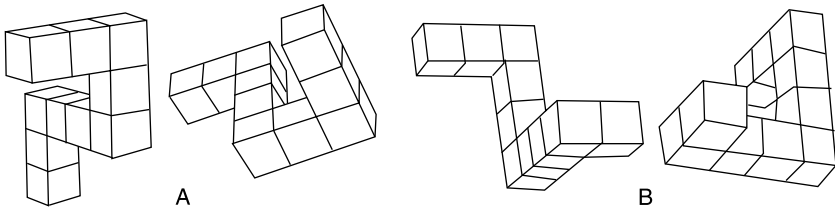


Figure 3.14 A classic mental rotation problem. For each pair of figures, determine if they can be rotated so that the two figures in each pair are identical.

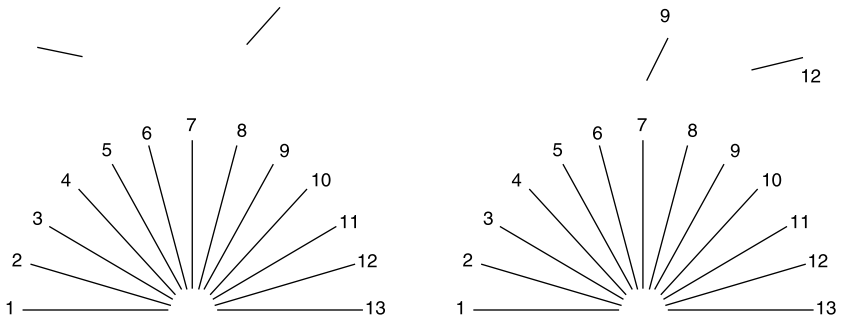


Figure 3.15 Judgment of line orientation task. Participants match each of the target line segments in the top half of each item with a numbered line from the bottom half. Answers are shown for the right-hand figure. Figure from Collaer and Nelson (2002). Copyright © 2002, with permission from Elsevier.

Sex differences in mental rotation have been studied for over 25 years and findings have been summarized in several meta-analytic reviews. A recent review of the sex differences literature on mental rotation found that male performance exceeds that of females across all age ranges, with the size of the between-sex difference ranging between $d = 0.52$ and $d = 1.49$, which increases slightly across the life span (Geiser, Lehmann, & Eid, 2008).

Another visuospatial task that shows very large sex differences and requires memory for different orientations is the judgment of line and angle orientation task (Collaer & Nelson, 2002). Look at Figure 3.15. There is a “fan” of lines at different orientations. In this task, participants examine the two lines above the fan and then indicate which of the lines in the fan matches the degree of tilt of these two lines. The answers for the lines in the figure on the right are provided. The first line matches line 9 in its orientation and the second line matches line 12 in its orientation. This task shows very large sex differences, typically at $d = 0.85$, with males showing better ability at matching the tilting line.

In a combined study of mental rotation and line angle judgments with more than 90,000 women and 111,000 men from 53 countries, men outperformed women in every country, but there were large between-country effects (Lippa, Collaer, & Peters, 2010). The many possible reasons for cognitive sex differences are discussed in following chapters; however, I note here a critical finding. Across nations, higher levels of gender equality and economic development were significantly associated with larger sex differences favoring males on both visuospatial tasks. The data from this massive cross-national study are shown in [Figure 3.16](#). I discuss these findings in more detail in [Chapter 7](#), where cultural influences on cognitive sex differences are considered.

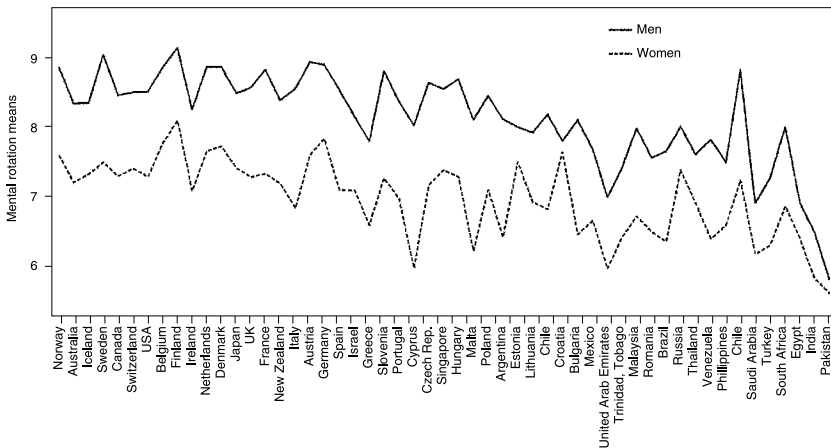
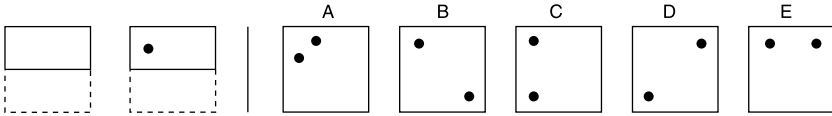


Figure 3.16 Men outperform women on mental rotation and judgment of line orientation tasks in 53 countries, but differences are largest in countries that are higher on gender equity and economic development measures. From Lippa, Collaer, and Peters (2010). Reproduced with kind permission from Springer Science + Business Media.

3. *Spatial visualization* refers to complex and analytic, multistep processing of spatial information. Tests that tap spatial visualization are the Embedded Figures Test, paper folding, hidden figures, and spatial relations test. In general, sex differences tend to be small on tests of spatial visualization, but when they are found, they tend to favor males (Miller, Halpern, & Saeta, 2010). A sample item from the paper folding test is shown in [Figure 3.17](#).

4. *Spatiotemporal ability* involves judgments about and responses to dynamic (i.e., moving) visual displays. There are several different tasks that involve information that is moving, such as having subjects press a key when a target is coincident with a stationary line (Smith & McPhee, 1987) and making “time



The correct answer to the sample problem above is C and so it should have been marked with an X

Figure 3.17 Imagine that the paper on the left is folded as shown and then has a hole punched in it. Which of the stimuli on the right shows what the paper will look like when it is unfolded?

of arrival” judgments about a moving object (Schiff & Oldak, 1990). A schematic diagram of a time of arrival task is shown in [Figure 3.18](#). Investigators have concluded that the ability to reason about dynamic visual displays is correlated with, but different from, the abilities used in reasoning about static displays (Hunt, Pellegrino, Frick, Farr, & Alderton, 1988).

Robust sex differences favoring males are found when the task involves movement-related judgments such as judging velocity (Law, Pellegrino & Hunt, 1993). Hancock (2011) believes that sex differences in time perception are important in determining sex differences in visuospatial abilities. If, for example, women are less accurate than men in estimating time intervals, their poorer performance on dynamic visuospatial tasks may be caused by discrepancies in their estimation of the time that it will take a ball to pass behind an opaque screen. This is an interesting hypothesis, but thus far, we have no direct tests of this relationship.

Although it is difficult to isolate any single factor that might be responsible for these results, judgments concerning dynamic visual displays must involve

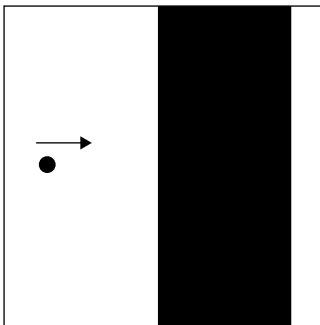


Figure 3.18 A moving ball is obscured by the solid area on a computer screen. Press a computer key when you expect it to be visible on the other side of the solid area. Reaction times are recorded.

time estimation in some way (i.e., when will the moving object reach a destination). In an effort to identify which components of a dynamic spatial task show sex differences, researchers compared performance factors, which can be defined as the components that make up a more complex task (Contreras, Rubio, Pena, Colom, & Santacreu, 2007). The researchers tested over 2,500 applicants for a training course in air traffic control. They used a computerized test of dynamic spatial ability called the Spatial Orientation Dynamic Task (SODT). It looks like a computer game in which the player can move two different colored dots using directional arrows. An example of a trial from the SODT is shown in [Figure 3.19](#). The goal is to guide the dots toward a target. The researchers measured reaction times (how long it took the players to respond by pressing an arrow key to change the direction of a moving dot), response frequency (how many times the players pressed the arrows on each trial), and invested time (time from the first press to the last press). The main

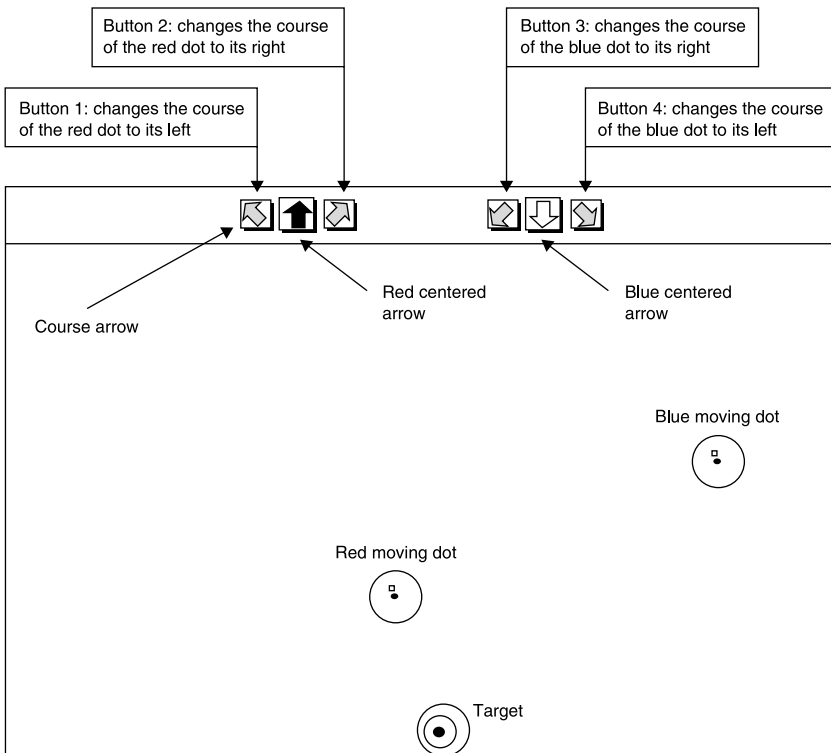


Figure 3.19 A computerized game set-up that was used to study sex differences in dynamic spatial ability. From Contreras, Rubio, Pena, Colom, and Santacreu (2007). Reproduced with kind permission from Springer Science + Business Media.

measure was the distance between the dot and the target. They found large effect sizes, favoring males. Thus, like earlier research, this new computerized measure of dynamic spatial ability showed large sex differences.

5. *Generation and maintenance of a spatial image* requires participants to generate an image (either from long-term or short-term memory) and then use the information in the image to perform a task. An example of a generation and maintenance task is shown in [Figure 3.20](#). Performance factors in visuospatial imagery were investigated by Loring-Meier and Halpern (1999) with a set of four tasks. These tasks were developed by Dror and Kosslyn (1994) for use in a study on age-related differences in visual imagery. In one of the tasks, participants had to generate an image of a capital letter and then decide if the letter would cover a portion of a rectangular frame. A second task required participants to create a visual image of a geometric figure that had just been displayed (i.e., without retrieval from long-term memory) and then make a similar spatial judgment. A third task required participants to scan an image that they retrieved from long-term memory, and a fourth task required the mental rotation of an image. In all four tasks, the male participants were significantly faster than the female participants, with no differences in accuracy (all *ds* between 0.63 and 0.77). The faster response times for the males could be reflecting an actual difference in the time it took to perform the cognitive tasks, but it also could be reflecting greater confidence on this task. There are cognitive tasks on which females, generally, show faster responding, so these results are not simply a matter of motor speed needed to respond or a general reflection of confidence or cautiousness. Readers are asked to keep all of these possible explanations in mind as they review the theories and research presented in later chapters.

Given the large variety of tests that have been used to measure visuospatial ability, it is not surprising that sex differences depend on the type of test used. Not coincidentally, this is an area replete with contradictory findings because of the multidimensional complexity of visuospatial abilities. Caplan,

(1) Image a capital letter “b” on the grid at right.

(2)

(3) Does the capital letter “b” cover the solid square?

(4) Press one computer key for “yes” and a different one for “no.”
(Reaction times measured)

Figure 3.20 Generation and maintenance of an image.

MacPherson, and Tobin (1985) questioned the legitimacy of the assumption that the construct “spatial abilities” exists. They believe that the entire notion suffers from a “definitional dilemma.” As noted in a response to Caplan, MacPherson, and Tobin (Halpern, 1986), much of the confusion in this area is attributable to the types of spatial ability tests used. Numerous researchers have attempted to define “spatial abilities” and “spatial thinking skills” (e.g., Chatterjee, 2008; Hegarty, 2010; National Research Council, 2006). Regardless of which definition is used, sex differences in spatial tasks are among the largest sex differences.

Visuospatial Knowledge and Memory

Spatial abilities are important in many areas of math and science. Consider for example, the pulley system shown in [Figure 3.21](#). In order to understand how the system works, individuals must be able to visualize movement from static displays.

Caplan, MacPherson, and Tobin (1985) noted that the types of tasks that are used to assess spatial ability are fairly abstract and that a much more valid test would involve finding one’s way in a real-world environment. This is certainly

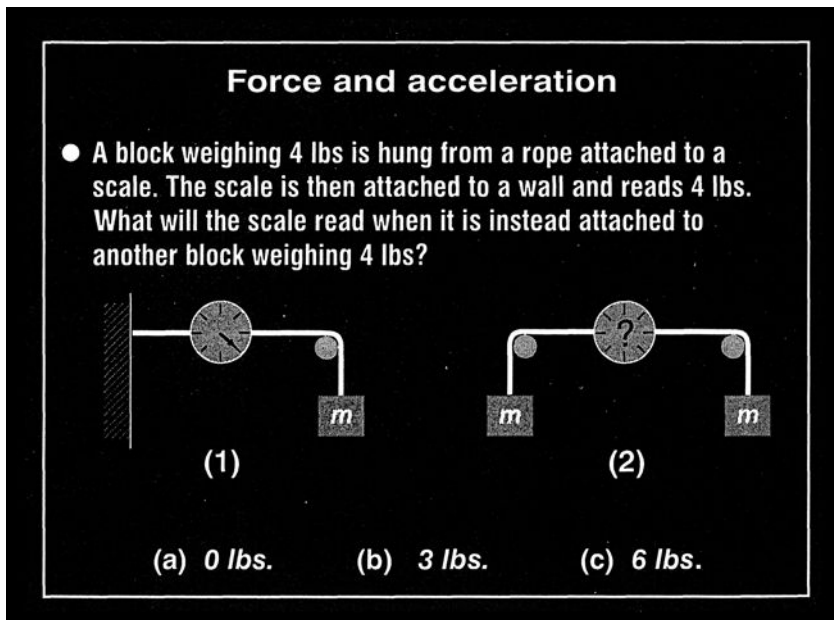


Figure 3.21 In this diagram of a pulley system, the reader needs to be able to imagine the simultaneous movement of multiple pulleys to understand the underlying physics principles.

a sensible suggestion, even though spatial ability tests that are conducted outside of the laboratory are more difficult to administer. There is always the problem that some subjects will have greater knowledge of a given geographical area. Furthermore, subjects could rely quite well on verbal strategies when they have to maneuver through a real-world space (e.g., turn at the green house). The few studies that have investigated route knowledge and “way finding” tend to support laboratory findings. In general, men learn a route from a 2-dimensional map in fewer trials and with fewer errors than a matched group of females (Galea & Kimura, 1993). Beatty (2002) wondered if some part of the sex difference in knowledge of geography could be due to differential experience with driving. In general, men drive more often than women, and it is the driver who is responsible for knowing routes. He tested this possibility with samples of teens who were too young to drive and older adults where the discrepancy in the amount of driving between women and men is the greatest. He found that driving experience was not responsible for the sex difference in geographical knowledge. Instead, it seems that women are more likely to attend to landmarks and men are more likely to use directional cues and estimate distances.

Data from the National Geography Bee tell a very compelling story. Liben (1995) estimated that 6 million school children in the United States participate in this competition. She describes “a shocking gender disparity among winners at every level” (p. 8). In 1993, of the 18,000 school winners, approximately 14,000 were boys; of the 57 state winners (including U.S. territories) 55 were boys; and in most years, all 10 finalists were boys, despite the fact that girls and boys participate at almost equal rates. Liben found that geography is not a stereotypically male domain (unlike other fields like “being a plumber” or “fixing cars”). She reported that the boys were more interested in geography and liked it more than the girls did. Furthermore, these huge sex ratios are not a fluke that is unique to samples from the United States. They are similar to those found with the International Assessment of Educational Progress that samples students from many countries. It is now over 15 years since Liben’s highly publicized studies showing huge sex differences in winners of the geography bee, and there are still very few girls who make it to the final rounds of competition. A geographer, Eric Clausen, recently sued the National Geographic Society (Kolpack, 2011; Turley, 2011), alleging that in the 19-year history of the National Geography Bee, only two national winners have been girls. Clausen noted that in 2009, only 2 out of 54 state winners were girls. But, as the court and others have responded, the fact that there are very few girls winning the National Geography Bee does not mean that the competition is discriminatory. Lynn Liben, the leading developmental expert on children’s understanding of space, responded that “From what I can tell at this point, the bottom line answer is that the same kinds of experiences, skills, interests and so on that lead boys to do well on the bee, also lead girls to do well on the bee. But boys have had more of those experiences” (Kolpack, 2011, para. 10).

A key question concerns possible sex differences in the ability to navigate through real space, which is sometimes called “way finding.” Wolbers and Hegarty (2010) reviewed the research literature on what determines navigational abilities. According to their review, there are multiple demonstrations that males have the advantage when learning from virtual maze tasks (i.e., mazes presented on the computer) and when learning from navigating through the world. Women typically report that they use landmarks (Turn left at the bank), whereas men more often report using cardinal directions (Turn north) and distance (Turn after 3 miles). As discussed in later chapters, these differences are found in other nonhuman mammals.

Even if women, in general, use different navigation cues, there are no data to support the notion that females are less able drivers than males. In fact, all of the data suggest that the opposite is true—women have far fewer automobile accidents and auto citations than men. According to a report on insurance risk prepared by the Social Issues Research Centre (2004, p. 4): “In all studies and analyses, without exception, men have been shown to have a higher rate of crashes than women. This gender difference is most marked in the population under the age of 25 years, but is also evident among older drivers.” Differences seem to be due to a greater male propensity to speed. These and similar findings about increased accidents of all sorts for males lead to this conclusion by the World Health Organization (2002): “Masculinity may be hazardous to health.”

As noted earlier in the section on memory, Voyer, Postma, Brake, and Imperato-McGinley (2007) conducted a meta-analytic review of 123 different findings from 36 studies on memory for location. They analyzed separately for object identity memory, which is memory for objects that were shown, usually on a paper display, and memory for location, which is memory for where on the display different objects were displayed. They found that across studies, females performed significantly better than males on both tasks ($d = 0.23$ for object memory and $d = 0.27$ for location memory), after the age of 13. It is difficult to know if differences might occur prior to age 13 because there were few studies that included young children.

Most major reviews of the literature have concluded that males are more variable in their visuospatial performance than females (e.g., Willingham & Cole’s, 1997, review of hundreds of tests, many with spatial ability components). Hedges and Nowell (1995) conducted a meta-analysis of many types of tests and also concluded that males are more variable than females in their spatial ability. The finding of greater variability in male performance on spatial tasks is theoretically important because one hypothesis about the cause of the sex difference is that many females do not use a spatial-imagery strategy to solve problems that are spatial (e.g., geometry problems). Perhaps some try to visualize an answer and others try to use verbal labels. If the sex difference in spatial ability were caused by the fact that more women than men use inappropriate strategies, then the females should show more variable

performance than the males. Given the opposite finding, it seems unlikely that females use a greater variety of strategies with these tasks.

Age Trends in Visuospatial Abilities

The male advantage in spatial abilities is evident throughout the life span.

—Elizabeth J. Meinz and Timothy A. Salthouse (1998, p. 56)

Many of the differences in visuospatial abilities appear early in life. How early? Moore and Johnson (2008) tested sex differences in mental rotation skills in 5-month-old infants. Readers may be wondering how anyone gets infants to respond to a mental rotation task. The researchers used a research paradigm that is commonly used with infants. It is called a habituation task. The underlying idea is that infants will look longer at novel stimuli than they will at familiar stimuli. In the jargon of psychology, infants habituate to familiar stimuli and stop looking at them. Using this paradigm, Moore and Johnson evaluated the hypothesis that infants can mentally rotate visual stimuli through 3-dimensional space and investigated possible sex differences in performance. They reasoned that if infants recognized that a familiar object was the same except for its orientation, then they should look at it for a shorter amount of time than they would for the mirror image of the same object, which would be a novel stimulus for the infants. They tested 20 female and 20 male 5-month-old infants (plus another 5 that were not included in their data analysis because of “fussiness” and “sleepiness”—a common problem when doing research with infants). The male infants looked longer at the novel objects than they did at the familiar ones, with no difference in looking times for the female infants. The effect size for this sex difference in looking time was $d = 0.66$, which is a fairly large effect.

Amazingly, Quinn and Liben (2008) used a similar paradigm with 3- to 4-month-old infants. Their stimuli were somewhat different, but like Moore and Johnson (2008), they found that male infants showed a novelty preference that indicated that they could tell the difference between the mirror image of a familiar stimulus and the same stimulus in a novel orientation (rotated in space to a tilt that had not been seen before). In an earlier version of this book, I wrote that sex differences in visuospatial processing can be found as early as it can be tested, which at the time was age 3. It is now clear that these sex differences occur very early in life and can be found with 3-month-old infants.

In the section on verbal abilities, I reviewed a 10-year follow-up study conducted by De Frias et al. (2006) in which they tested groups of people ranging in age from 35 to 80 years old and then retested them 10 years later. They concluded that the female superiority on many verbal tasks remained the same over the intervening decade. In the same study, they also assessed visuospatial abilities using the block design test which is part of the WAIS. They

found that the male advantage on measures of visuospatial abilities did not change over the 10-year period between test administrations.

Meinz and Salthouse (1998) posed a question that is of great interest in an aging society, “Is age kinder to females than to males?” They examined data from 25 separate studies that compared men’s and women’s cognitive abilities in old age with those of younger adults. For the older group, they found the same overall pattern of cognitive sex differences that has been reported with younger age groups: older women are faster than older men on speeded perceptual tests and are slightly better on verbal fluency tasks (in this study it was nonsignificant). Older men scored considerably better than older women on visuospatial tasks and somewhat better on working memory tasks (which may be associated with the type of memory tasks they used). It is comforting to know that although the older adults declined in most cognitive abilities, especially visuospatial ability, they showed increases in knowledge into old age and no change in verbal fluency. When Jansen and Heil (2010) examined the aging question using mental rotation tasks, they found the typical large effect size favoring males for young adults aged 20 to 30 years ($d = 1.07$), with smaller effect sizes for the sex differences at ages 40 to 50 and 60 to 70 ($d = 0.53$ and $d = 0.59$, respectively). The decline in the effect size for older adults probably reflects two processes. First, performance declined for both women and men with age, and the overall low rate of correct responses could be causing a floor effect, and second, there is some evidence that these abilities decline more rapidly in old age for men. Overall, it does seem that age is kinder to women, at least when some cognitive abilities are concerned.

The conclusion that age is kinder for women was replicated in the massive study sponsored by the BBC that collected data on the internet. Researchers found that men performed better than women on an internet version of the mental rotation task ($d = 0.49$) and the judgment of line orientation task ($d = 0.57$), and although performance declined with age from ages 20 to 60, the decline was greater for the men (Maylor et al., 2007). The data from Maylor et al. are shown in [Figure 3.22](#).

Cognitive Styles

There has been considerable interest in recent years in the notion that males and females may have different cognitive styles. The term “cognitive styles” does not have an intuitive meaning. In general, it refers to individual differences in modes of perceiving, remembering, and thinking (Kogan, 1973). It was a popular area of interest during the 1960s and 1970s. It is used by some psychologists in conjunction with the concept of psychological differentiation (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962). An individual who is highly differentiated can separate herself or himself from the environment and can separate items from each other in the environment. According to the theory of psychological differentiation, we all differ in terms of how well we can

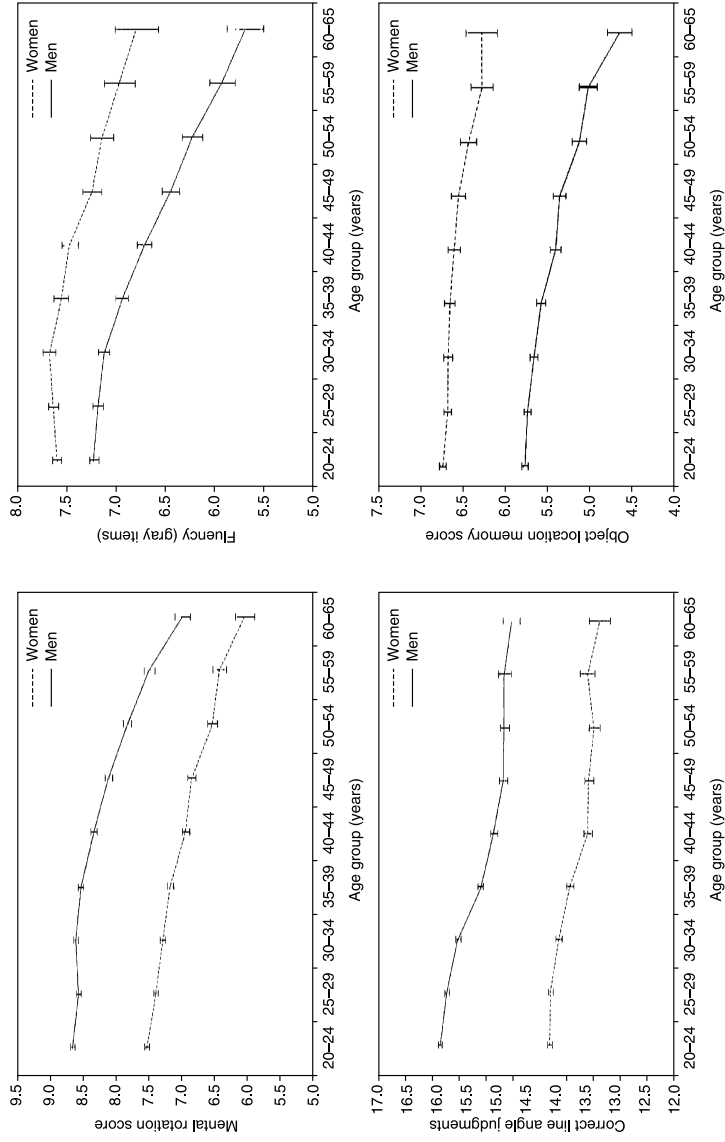


Figure 3.22 Data from BBC internet study showing that at every adult age, women outperform men on a measure of verbal fluency (naming words that belong in categories) and memory for object location and men outperform women on mental rotation and judgment of line orientation tasks. From Maylor et al. (2007). Reprinted with kind permission of Springer Science + Business Media.

separate items in the environment. There are several dimensions or aspects of psychological differentiation. One dimension along which the sexes are said to differ is in field articulation or “field dependence and independence.” These terms were coined by Witkin and have been used to characterize the degree to which subjects are influenced by objects in their visual field.

One way of assessing field dependence and independence is with the Rod and Frame Test. In this test, subjects are seated in a darkened room and are presented with a luminous rectangle (the frame) that has a luminous rod positioned inside of it. The rectangle is rotated to different orientations by the experimenter. The task for the subject is to position the rod so that it is vertical. [Figure 3.23](#) shows a schematic drawing of two rod and frame combinations with which participants could be presented. Some subjects’ judgments of true vertical for the rod are influenced by the tilt of the frame surrounding the rod. They are labeled “field-dependent.” Other subjects’ judgments of true vertical for the rod are not influenced by the tilt of the frame surrounding the rod. They are labeled “field-independent.” In general, sex and age differences are found with the Rod and Frame Test (although differences are not unanimously reported). The usual findings are that children are more field dependent than adults, and females are more field dependent than males.

Measures of field dependence and independence obtained with the Rod and Frame Test are highly correlated with measures obtained with a test known as the Embedded Figures Test. In the Embedded Figures Test, subjects are shown a simple geometric form and then must maintain it in memory and pick it out from a more complex form. Sample items similar to those found in the Embedded Figures Test are shown in [Figure 3.24](#).

Both the Embedded Figures Test and Rod and Frame Test require the subject to segregate a geometric form from its context (the form is either an embedded multi-sided figure or the rod), and in both tests females are more influenced by the context than males. Field dependence was historically hypothesized to reflect personalities that are conforming, submissive to authority, into comfortable ruts, and passive (Elliot, 1961). Women’s field dependence was described

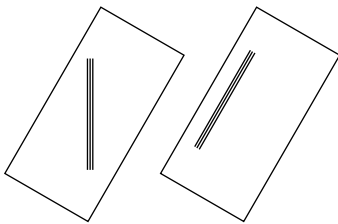


Figure 3.23 A schematic diagram of the Rod and Frame Test. The instructions are, “Align a rod within these frames so that it is vertical” (ignoring the tilt of the screen).

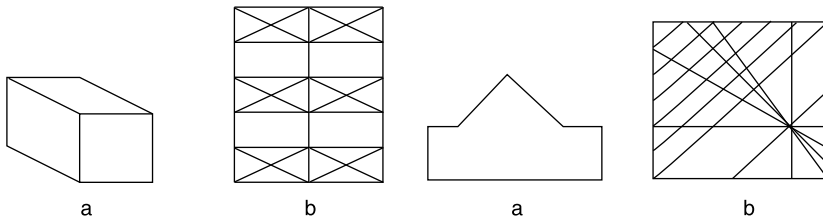


Figure 3.24 Embedded Figures Test. Is Figure (a) part of Figure (b)?

as “accepting the field more passively than men” (Sherman, 1967, p. 290). On the basis of these test results, women’s cognitive style was described as “global,” “conforming,” and “child-like.” According to Witkin et al. (1962), it was similar to the undifferentiated thought processes found in “primitive” cultures. The field independence associated with male performance was described, by contrast, as reflecting a cognitive style that is “analytic” and “self-reliant.” (The value-laden bias in these descriptive terms should be too obvious to require comment.) Witkin et al. believed that because women are unable to maintain a “sense of separate identity” (p. 218), they were less skilled at certain types of problem solving, more likely to conform to group pressure, and more concerned with the facial expressions of others. Thus, different cognitive styles were ascribed to men and women on the basis of their performance on these two tests.

It would appear, however, that spatial tests of field dependence and independence are not indicative of cognitive styles, that is, they are unrelated to passivity or submissiveness, notwithstanding the claims of Witkin (1950; Witkin et al., 1954) and others, but merely reflect sex differences in visuospatial abilities. Several researchers have argued that sex differences in field independence are an artifact of sex differences in visuospatial ability because both the Rod and Frame Test and the Embedded Figures Test have a strong spatial component (Sherman, 1967). This is yet another example of the important distinction between experimental results and the explanations that we “invent” for them. Somehow a test of visuospatial ability came to be used as an indicator of personality traits and the inferiority of women.

A similar and more modern example is the idea that women are biologically predisposed to empathize and men are biologically predisposed to synthesize (Baron-Cohen, Knickmeyer, & Belmonte, 2005). This theory is described in more detail in [Chapter 5](#). As readers might expect given the distinction between field-dependent and field-independent styles, the style associated with being female is purported to be less compatible with careers in science and engineering than that associated with being male. This distinction has been

pilloried in recent books on using science to support a sexist agenda, including books by Fine (2010) and Jordan-Young (2010).

QUANTITATIVE ABILITIES

The underrepresentation of women in mathematics related careers, long an issue of equity and justice, has serious economic implications as the United States faces a shortage of scientists, engineers, and mathematically trained workers.

—Penelope H. Dunham (1998, para. 1)

Plake, Loyd, and Hoover (1981) summarized findings of sex-related differences in quantitative (mathematical) ability this way: “There is little doubt that females score differently from males on mathematical tests” (p. 780). As you can probably guess, “differently” is a euphemism for poorer, but is this widespread belief that males outperform females in quantitative skills supported by data? The short answer is both yes and no.

It seems that quantitative abilities, like spatial and verbal abilities, are a heterogeneous concept. There are several different aspects of quantitative abilities, and there is good evidence that sex differences are manifested in only some of them. Examples of the types of tasks that are used to assess quantitative ability are shown in [Figure 3.25](#).

Janet Hyde and her colleagues (Else-Quest, Hyde, & Linn, 2010; Hyde, 2005; Hyde, Lindberg, Linn, Ellis, & Williams, 2008) have published a series of carefully conducted meta-analyses and, in all of their papers, they find support for the “gender similarity hypothesis,” which, as its name states, is the idea that males and females are fundamentally similar in most (but not all) measures. In one study (Hyde et al. 2008), the authors used data on mathematical achievement from several states in the United States. They compared the average math scores for girls and boys from Grades 2 through 11, and found virtually no difference in any of the grades (d s ranged from +0.06 to −0.02). But, as the authors noted, the tests were more heavily weighted with items that required lower level thinking (i.e., recall and skill/concept) rather than higher level thinking (i.e., strategic thinking and extended thinking). Thus, based on these data, there is little difference in the average performance of girls and boys in mathematics in Grades 2 through 11, at least when the problems are not very difficult. One major criticism of this study is that sex differences in mathematics become progressively larger as the sample becomes more selective and the type of math skill becomes more advanced. To test this possibility, the authors examined the ratio of males to females among the highest-scoring students. For White students scoring at the 95th percentile, the ratio of boys to girls was 1.45; for White students scoring at the 99th percentile (top 1% of all students), the ratio of boys to girls was

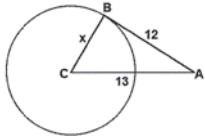
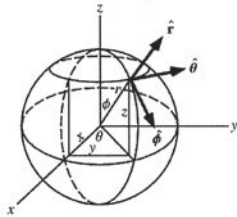
Algebra	Solve the set of equations for x and y. $\begin{aligned} 4x + 7y &= 10 \\ 5x + 3y &= -6 \end{aligned}$
Geometry	Find the value of x given that the segment AB is tangent to circle C at B. 
Geometry – advanced and highly spatial (introductory course in multivariable calculus in sophomore year for majors in many different STEM fields)	Express the Cartesian coordinates x, y, and z using the spherical coordinates ϕ, θ, and r shown below.  Figure is from http://mathworld.wolfram.co.in/SphericalCoordinates.html
Computation	$\begin{array}{r} 276 \\ \times 16 \\ \hline ? \end{array}$
Word problem	If Fred can paint a room in two hours and Sally can paint the same room in three hours, how long will it take them to paint the room if they work together?
Calculus (introductory college calculus course or advanced high school calculus course)	$\int x^2 \cos(x) \, dx = ?$
Mathematical proof (introductory mathematical analysis course for mathematics majors in their sophomore or junior college year)	Suppose a and c are real numbers, $c > 0$, and f is defined on $[-1, 1]$ by $f(x) = \begin{cases} x ^a \sin(x)^{-c} & (\text{if } x \neq 0), \\ 0 & (\text{if } x = 0). \end{cases}$ Prove that f is continuous if and only if $a > 0$. This problem is from Rudin (1976, p.115) Rudin, W. (1976). <i>Principles of Mathematical Analysis, Third Edition</i>. McGraw-Hill: New York.
Differential equations (in quantum mechanics) (introductory quantum mechanics course for physics majors in their sophomore or junior college year)	Consider a particle of mass m constrained to the 1-D potential of $V(x) = 0$ for $0 < x < L$, but $V(x) = 8$ otherwise. Solve Schrödinger's equation $i\hbar \frac{\partial(x, t)}{\partial t} = \left[-\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} + V(x) \right] (x, t)$ for the generalized eigenstate (x, t) of the energy operator $\hat{H} =$ $-\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} + V(x)$

Figure 3.25 Sample questions used to assess quantitative ability. I thank David I. Miller at University of California, Berkeley, for this figure.

2.06. The authors made the same comparison for Asian/Pacific Islander students and failed to find the same predominance of boys to girls among the highest scorers (ratio of boys to girls was 1.09 at the 95th percentile and 0.91 at the 99th percentile). Critics have noted that there were relatively few Asian/Pacific Islander students at the highest levels and that since the tests were at a relatively low level of difficulty, the data from the high achieving tail of the distribution are misleading because sex differences emerge on the more difficult test items.

Many researchers have argued that sex differences in mathematics reflect opportunity inequalities and economic opportunities (e.g., Else-Quest, Hyde, & Linn, 2010). To test this hypothesis, researchers analyzed large international data sets along with measures of gender equity and economic development. As you may recall, similar analyses were conducted with the international data regarding female and male differences on mental rotation and judgments of line orientation. The authors of the international math study found that there was only a small advantage for males, which was in contrast to the finding that males were much more confident in their math abilities than girls were.

Guiso, Monte, Sapienza, and Zingales (2008) analyzed cross-national data on math and reading scores. They found that there is considerable variability among countries, but on average, girls score lower than boys (the mean score for girls is 2% lower than the mean score for boys) in math, but when gender equality of the country was considered, these differences virtually disappear. It is interesting to note that when they performed these analyses on reading scores, the advantage for girls (which was 6.6% higher than the mean score for boys) increased. The authors conclude that “in more gender equal societies, girls perform as well as boys in mathematics and much better than them in reading” (p. 1165). I return to these data in [Chapter 7](#), where I discuss cultural influences on cognitive sex differences.

Recall that the section on sex differences in the tails of distributions showed that there are approximately 3 to 4 males for every female who achieves the highest scores among gifted students for mathematics (Wai, Cacchio et al., 2010). It seems reasonable to conclude that the average differences between females and males in math are small, but as the samples become more select, that is as ability levels increase, males outscore females. This conclusion is supported with data from both of the most commonly used standardized exams for college entrance—the SATs and ACTs. Sex differences on math tests are shown in [Figures 3.26](#) and [3.27](#). One reason why the average difference on the SAT-M is as large as it is may relate to the gender make-up of test-takers. Recall from an earlier section in this chapter that many more women take the SATs than men, which should result in a lower mean score because more women of lower ability are taking the SATs than men of lower ability. The differences in number of women and men who take the SATs mean that any conclusions about sex differences based on average SAT scores should be made with extreme caution.

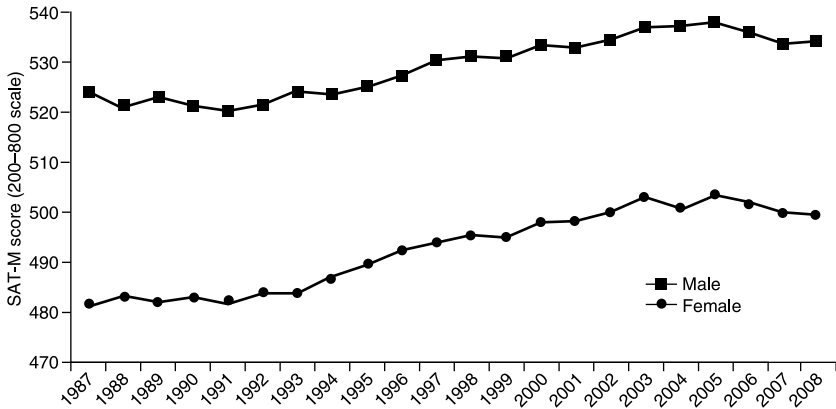


Figure 3.26 SAT mean scores in mathematics for females and males from 1987 to 2008. From Hill, Corbett, and St. Rose (2010). Copyright © 2006 The College Board. Reprinted with permission www.collegeboard.com. Data for 2007 and 2008 from College Board, www.collegeboard.com

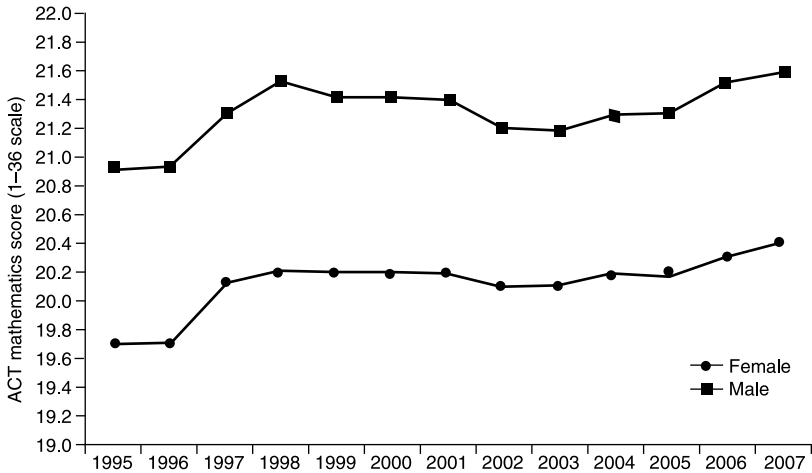


Figure 3.27 ACT mean scores in mathematics for females and males from 1995 to 2007. Unpublished data provided by the ACT Statistical Research Department. Reprinted with permission of ACT, Inc.

Age Trends in Quantitative Abilities

Sex differences in quantitative abilities vary throughout the life span. For example, among young children (ages 4 to 10 years) girls and boys perform similarly on tests of primary mathematical reasoning abilities (Spelke, 2005).

During or shortly after elementary school, however, when quantitative tests become more complex and more visuospatial in nature, sex differences emerge and continue to grow thereafter (Beilstein & Wilson, 2000). By the end of their secondary schooling (12th grade), males demonstrate significantly higher achievement than females in the areas of number properties and operations as well as measurement and geometry (Rampey, Dion, & Donahue, 2009). This trend has remained steady since the early 1970s. Interestingly, females get higher grades than males in school in all subjects, including math, at all grade levels (Kimball, 1989; Snyder, Dillow, & Hoffman, 2009; Willingham & Cole, 1997) and do slightly better on international tests of algebra (U.S. Department of Education, 2005). But, when males and females are compared on tests that reflect content learned in school, such as state-wide assessment tests, the differences disappear. Although it should be noted that these tests tend to evaluate lower level skills and leave open the possibility of sex differences if higher order skills were assessed (Hyde, Lindberg, Linn, Ellis, & Williams, 2008). Math differences favoring males are larger and more commonly found on tests that are not directly tied to the curriculum, such as the SATs, which may reflect novel problem solving skills. On average, males taking the SATs have consistently scored about a third of a standard deviation higher than girls over the past 25 years (data from College Board, 2007; for a review see Halpern, Benbow, Geary, Gur, Hyde, & Gernsbacher, 2007a, b).

The overrepresentation of boys among the most gifted in mathematics can be detected at very young ages. In a study of mathematically precocious young children, Robinson, Abbott, Berninger, and Busse (1996) found that more young boys were referred for giftedness in mathematical reasoning than young girls, despite special attempts to include girls. They administered a test battery to 143 preschool girls, 167 preschool boys, 201 girls in kindergarten, and 248 boys in kindergarten who were identified as possibly having the potential for mathematical giftedness. In this select group, they found sex differences favoring the boys in tests of number knowledge, number series, numeration, problem solving, calculation, word problems, counting span, an arithmetic screening test, and a test of visuospatial span. These children were also administered three different verbal tests. Although the sex differences on the three verbal tests were not statistically significant, for all six comparisons (two age groups on three verbal tests), the girls scored higher than the boys. These authors reported sex differences in every analysis—more boys were nominated for the mathematically gifted program, a greater proportion of the boys qualified for admission to the program, and the boys scored higher than the girls on 8 of the 11 subtests. It is important to note here that sex differences are more commonly found in highly select groups, so these conclusions are not generalizable to children whose performance is closer to average.

THINKING ABOUT THE MAGNITUDE OF DIFFERENCES

Test performance may have real, quantifiable educational and social implications. Small mean differences combined with modest differences in variance can have a great effect on the number of individuals who excel.

—Michael Beller and Naomi Gafni (1996, p. 375)

Although the preponderance of the experimental evidence points to some sex differences in verbal, visuospatial, and quantitative ability, practical questions about the size or magnitude of these differences have not been easy to resolve. Are the differences trivial and of no practical significance or do they represent meaningful ability differences between the sexes? Even if we were to conclude that there are large between-sex differences with respect to a cognitive ability, it is very important to remember that most research analyzes group average results that cannot be applied to any individual.

A serious and common misunderstanding about sex differences is to conclude that “women are like this—men are like that” and then decide to treat each sex differently based on average differences. The focus on differences does tend to obscure the many more ways males and females are similar, and the way we think about group differences could prevent us from considering people as individuals. There is considerable overlap between the female and male distributions in every ability.

All of the cognitive sex differences have been replicated numerous times and are statistically significant, which means that they are unlikely to have occurred by chance, but are they of any practical significance? Can they be used to explain why we have so few female mathematicians or engineers? Can they help us predict a male’s or female’s ability to perform a task? Can they be used to justify discrimination? Are they merely curiosities whose only value is to keep psychologists (and publishers) busy? Answers to these questions are hotly debated and have important implications for modern society.

On an intuitive level, effect size is a quantification of the size of the average between-sex difference on a particular test or set of tests. Unfortunately, the numbers we use to express effect size are not intuitive. Differences like the finding that men tend to outscore women by an average of 40 points on the quantitative portion of the SATs have an immediate meaning to anyone who is familiar with the scoring system for the SATs. Unfortunately, sex differences in abilities are measured with many different tests and a common measure of the average difference is needed to make comparisons across many studies. The effect size statistic is used to convey the size of the differences when many different tests are used. (Readers for whom this is a new concept are referred back to [Chapter 2](#) where statistical concepts are discussed in more depth. It is also possible to follow the gist of the following discussion without

understanding the fine points of some of the statistical concepts that are discussed.)

There are few guidelines for determining if the size of a sex difference with respect to a cognitive ability is large enough to be important. Cohen (1977) provided an arbitrary statistical definition of small, medium, and large effect sizes using standard deviation units (0.20 SD is small, 0.50 SD is medium, and 0.80 SD is large). There is, however, no good reason to accept his effect size markers except for the fact that they provide a common ruler for comparing differences. It is important to realize that effect size should not be confused with importance. A small effect could still be important, depending on how importance is defined and who defines it. Percentage of explained variance statistics (e.g., omega squared, R^2 , eta squared) are useful in this regard, but they still leave us with the question of how much explained variance is large enough to be important. If sex explained 5% of the variance in the data, is this a large or small number? In another context, like medicine, 5% of explained variance attributable to a treatment could mean many lives would be saved. Thus, the question of whether 1% or 5% or 50% of explained variance is important depends on both the context and value judgments. Value judgments never lend themselves to statistical analysis, and thus, precise answers to the question of how large does a difference have to be to be important will remain debatable.

In one of the most lucid discussions on how to interpret effect sizes, Rosenthal and Rubin (1982) attempted to shed light on the question of how large an effect size must be in order to be of practical importance. As described in [Chapter 2](#), they used a statistical test known as the binomial effect size display (BESD). They calculated that when sex explains only 4% of the variance in test scores, this translates into distributions in which 60% of the higher scoring sex is above the median and only 40% of the lower scoring sex is above the median. They argue that outcome rates of 60% versus 40% are important because they can be used to predict performance on ability tests in these areas. Here is how they explained their reasoning:

We do not agree that gender is a poor predictor of one's performance on ability tests. If obtaining a particular job required scoring above the median on a test that correlated .20 with being female, then for every 100 females and 100 males that applied, 60 of the women, but only 40 of the men would be job eligible. (p. 711)

They also looked at the consistencies among effect sizes across 12 studies of verbal ability, seven studies of visuospatial ability, seven studies of quantitative ability, and 14 studies of field articulation (field independence and dependence). They concluded that effect sizes differed from study to study, supporting the idea that the magnitude of the sex difference in any area depends on the type of test used.

UNDERLYING COGNITIVE PROCESSES

Examining sex differences for cognitive abilities is only one way of conceptualizing how females and males may differ in their intellectual processes. The division of abilities into verbal, visuospatial, and quantitative has been useful, and as discussed in the next two chapters, each of these abilities has distinct biological correlates. But, there are other ways of investigating the thinking process. One such way is to consider what the subject does when he or she is engaged in a particular task. This alternate approach can be thought of as examining the underlying cognitive processes.

Look carefully at [Table 3.1](#). I have listed the types of tasks on which females tend to excel and the types of tasks on which males tend to excel. One approach is to consider these two types of tasks as representing different underlying cognitive processes. The tasks at which females excel include language production, reading, writing, generating synonyms, word fluency, memory for words, objects and locations, and algebra. (Algebra may have a more language-like structure than other types of mathematics.) These are high-level tasks that require rapid access to and retrieval of information that is stored in memory and the use of language in manipulating and creating information. On the other hand, consider those tasks at which males tend to excel—mathematical problem solving, verbal analogies, mental rotation, spatial perception, and

Table 3.1 Possible sex differences in underlying cognitive processes

Tasks at which females excel:

- Generating synonyms (associational fluency)
- Language production and word fluency
- Computation
- Anagrams
- Memory for words, objects, personal experiences, and locations
- Reading comprehension and writing

Underlying cognitive processes: rapid access to and retrieval of information in memory

Tasks at which males excel:

- Verbal analogies
- Mathematical problem solving
- Mental rotation and spatial perception
- Spatiotemporal tasks (dynamic visual displays)
- Generating and using information in visual images
- Mechanical reasoning and some science-related topics

Underlying cognitive processes: maintaining and manipulating a mental representation in visual-spatial working memory

using information in dynamic visual displays (spatiotemporal tasks) and visual images. These sorts of tasks require the ability to maintain and manipulate mental representations. Thus, it may prove meaningful to differentiate cognitive tasks on the basis of the type of cognitive process that each requires. When we adopt this framework, we can account for sex differences that do not divide neatly under the tripartite cognitive abilities rubric (verbal, mathematical, and visuospatial) and we can incorporate female superiority on some visuospatial and mathematical tasks and male superiority on some verbal tasks.

ARE SEX DIFFERENCES DECREASING?

Contrary to the findings of small scale studies, these average differences do not appear to be decreasing but are relatively stable across the 32-year period investigated.

—Larry V. Hedges and Amy Nowell (1995, p. 45)

The next four chapters will describe theories that have been proposed to explain why sex differences are sometimes found. If these differences were created by sex-differentiated psychosocial variables like sex roles and different rewards for males and females, then we would expect to see some decline in the magnitude of the differences as the impact of sex roles diminishes for a variety of reasons including the fact that women have increasingly greater access to economic, educational, and political opportunities over time. Thus, the question of whether sex differences in cognitive abilities are decreasing is important. In order to conclude that sex differences are decreasing, we need to have comparable samples of subjects that have taken the same cognitive abilities tests in different time periods. There are few samples that meet these stringent requirements.

Several experimenters have examined effect sizes as a function of the date that the study was published. The underlying rationale for investigating results as a function of their date of publication is that more recent studies should, in general, show smaller sex differences than studies published many years ago, if sex differences really have been decreasing. The problem with this approach is that a great many other variables have also changed during the intervening years. In response to concerns that publication practices tend to be biased toward studies that report significant differences, many more journals and paper presentations now report nonsignificant results, thus changing the nature of the studies that can be included in meta-analyses. (In other words, a study that fails to find significant differences is more likely to be published than in the past.) The more recent tendency to publish nonsignificant results would cause effect sizes to decrease as a function of publication date.

The nature of samples has also changed with time. Women surpassed men in college enrollments in the United States in 1982. Currently women comprise approximately 56% to 57% of college enrollments, with higher proportions in

community colleges than in 4-year colleges (Peter & Horn, 2005). Because a larger percentage of all females are now attending college than the percentage of males, a more select group of college men is probably being sampled than college women. The nature of many of the tests has also changed. The Educational Testing Service, which authors the SATs, has come under severe criticism for the disparities in female and male scores. Accordingly, they have responded in the last few years by scrutinizing every test question for sex-related bias in content or use of pronouns. The Educational Testing Service now trains all of its test committees on ways to avoid bias in the questions that are used in their examinations. Many of the other tests that show the greatest sex differences have been developed within the last few years (e.g., paper and pencil mental rotation tests, word fluency, and consonant–vowel matching tests) and therefore cannot be compared with comparable older studies to see if the effect sizes are diminishing. The SATs were substantially changed in 2005, which makes comparisons from earlier years more difficult.

The data on right-tail ratios clearly show a decrease in the proportion of males to females among highest scorers in math and verbal skills (Wai, Cacchio et al., 2010). As noted earlier, the ratios were reduced from 13:1 to between 3:1 and 4:1 for mathematics, with the latter value remaining constant over the last 20 years. So, when considering the highest scores, it does seem that there has been a reduction in the size of sex differences, at least on some standardized tests of mathematics. Differences are clearly small for average performers in mathematics, which may also be a reduction in the size of sex difference, but as the international study by Guiso et al. (2008) showed, we can expect the female advantage in reading to grow larger as more societies achieve gender equality and continued economic development. Like every conclusion in this text, the answers are not simple.

Very large sex differences are found on some visuospatial tasks, most notably mental rotation and judgments of line orientation. The effect sizes have remained between $d = 0.8$ and $d > 1.0$ for several decades, so it does not appear that the female–male difference in mental rotation is changing. Finally, for judgments of line orientation, there are not enough data from earlier decades to determine trends over time.

SIMILARITIES

Although the focus of this chapter has been the identification of cognitive abilities that show sex differences, the flip-side of this issue is at least as important—those areas of cognition in which similarities are found. I have focused on differences because the logic of hypothesis testing only allows conclusions about differences. Despite this limitation, it is important to note that the number of areas in which sex differences are even moderate in size is small. Males and females are overwhelmingly alike in their cognitive abilities. It is

important not to lose sight of this fact as we consider theories that have been posited to explain the differences and similarities in cognitive sex differences. Also, please keep in mind a point that I repeat in several places in this book: even in the relatively few areas in which differences are found, these conclusions are based on data gathered from a large number of subjects. They cannot be applied to any single individual because the within-sex variability is so large.

CHAPTER SUMMARY

Although sex differences have not been found in general intelligence, there are some types of cognitive abilities that vary, on the average, as a function of sex. There are some sex-related differences in the earliest stages of information processing—perception and attention—but the effect of these early stage differences on later cognitive processes is unknown and we cannot conclude that they are responsible for differences in cognitive abilities. Males comprise a disproportionate share of the extremely low ability end of the verbal abilities distribution, with males overwhelmingly categorized as stutterers, dyslexics, and low IQ. By contrast, females excel at general and mixed verbal ability tests, speech production, writing, memory for words, objects, and locations, (some) perceptual motor skills, and associational fluency. These differences appear as soon as speech and language usage begin.

There are few differences in quantitative abilities for most of the population—that is, the middle range of the ability distribution, but there are 3 to 4 times more males scoring at the highest levels on standardized tests of mathematics that are designed for use in college and beyond. Similarly, there are disproportionately more females at the high ability end on writing tests and (to a lesser extent) on tests of verbal reasoning. There are at least five types of visuospatial ability that have been identified: spatial perception, mental rotation, spatial visualization, spatiotemporal ability, and generation and maintenance of visual images. Sex differences favoring males are found on all of them except spatial visualization, which typically does not show sex differences, but when sex differences are found, they favor males. The effect sizes for mental rotation and judgments of line orientation are among the largest found in the literature and can be found developmentally—in infants as young as 3 months old for mental rotation. The effect size for visuospatial abilities has remained unchanged for many decades. An analysis of the underlying cognitive processes was proposed, with males performing especially well on tasks that involve maintaining and manipulating mental representations and females performing especially well on tasks that require rapid access to and retrieval of information from memory, especially when the information is verbal. It is important to keep in mind that the list of cognitive differences is relatively small and that cognitive similarities between the sexes are greater than the differences.

Biological Hypotheses Part I: Genes and Hormones

CONTENTS

- What Makes Us Female or Male?
 - Categories of Maleness and Femaleness
- The Notion of Biological Determination
 - The Zeitgeist for John/Joan
 - Are Biological Theories Sexist?
- Behavioral Genetics
 - Are Females and Males Affected Equally by Heredity?
 - Sex-Linked Versus Sex-Limited
 - Molarity or Modularity?
 - Theories of Genetic Effects on Cognition
 - Arguing From Genetic Abnormalities
 - The Genetics of the Environment
- Sex Hormones
 - Some Basic Biology Needed to Understand Hormones
 - Theories Relating Sex Hormones to Cognitive Abilities
 - Arguing From Hormonal Abnormalities
 - Do Cognitive Abilities Vary Over the Menstrual Cycle?
 - Hormone Replacement Therapy
 - Sex Hormones, Sexual Orientation, and Cognition
- Chapter Summary

After sexism is stripped away, there will still be something different—
something grounded in biology.

—Michael Konner (1988, p. 35)

Perhaps this chapter and the next should come with a warning similar to the ones found on cigarette advertisements:

WARNING: Some of the research and theories described in this chapter may be disturbing to your basic belief systems.

I have taught this material many times, and there have always been students who are profoundly disturbed by the possibility that even a small portion of the sex differences in cognitive abilities may be attributable to biological factors. When reading this chapter and the following one devoted to sex-related brain differences, it is important to keep in mind that even if we were to conclude that biological variables are partial determinants of sex differences in cognitive abilities, the importance of psychosocial factors is not necessarily diminished. Biological and psychosocial variables interact in their influence on the development of individuals, and although biological and psychosocial hypotheses are presented in separate chapters, this organization is not meant to imply that they are diametrically opposed or independent concepts. As you read the chapters that focus on biological and environmental factors, keep in mind the biopsychosocial model that was presented in the opening chapter of this book—it is an integral conceptualization of nature and nurture. In order to understand broad topics, like the variables that create and influence human cognition, we have to break them down into smaller units, but they also have to be “put back together again,” a feat that is accomplished in the last chapter.

WHAT MAKES US FEMALE OR MALE?

Medicine is clueless as to how males and females really differ from each other.

—Bruce McEwen, neurobiologist (2009, para. 3)

This may seem like a strange question, but in fact, deciding who is male or female is often not as simple as examining one’s genitals. Consider the highly publicized case of Caster Semenya. Ms. Semenya, shown in [Figure 4.1](#), won the 800 meter race at the 2009 International Association of Athletic Federations (IAAF) meet in Berlin. She set a national record of 1:55.45 for the gold medal. This sensational athlete from South Africa sparked controversy when officials questioned her sex, presumably because of her muscular physique. She was required to take a “gender test” that included analysis by an endocrinologist (physician with expertise in hormones), gynecologist, and internal medicine expert. After considerable speculation, the IAAF determined that she would keep the gold medal and prize money winnings and that the results of the gender test would be kept confidential—strictly between the doctors and Ms. Semenya. The IAAF apologized for the embarrassment they caused Ms. Semenya (Cickay, 2009).

For many, the issues raised by questioning whether Ms. Semenya was a female or male are profoundly disturbing. We tend to think that male or female are mutually exclusive categories, but in fact, there are many ways to be considered female or male, and they are not always consistent within the same individual.



Figure 4.1 Caster Semenya, South African athlete who was required to undergo “gender testing” to determine if she could keep her medal for the world’s fastest 800 meter run, which she won at the International Association of Athletic Federations (IAAF) meet in Berlin in 2009 (Cickay, 2009). Photo by Luke Walker/Gallo Images/Getty Images.

Categories of Maleness and Femaleness

There are several categories of variables that are used to determine if someone is female or male.

Genes If you ask anyone on the street (the proverbial “person on the street test”) what determines if a fetus develops into a male or female, the most likely response will have something to do with genes. Sometime in school, most people learned that normally, humans have 23 pairs of chromosomes (46 chromosomes in total). One of these pairs is the “sex chromosomes”: The male configuration is XY, and the female configuration is XX. As we will review in this chapter, sometimes the sex chromosomes are not normal and individuals are born with only one X chromosome (45XO to designate that there is a total of 45 chromosomes and the missing chromosome is one member of the sex chromosome pair). There are also other irregularities that occur, and although they are relatively rare, there are large numbers of individuals worldwide with abnormal sex chromosomes.

Hormones Although all normal individuals have both types of hormones that are traditionally considered “male” and “female,” from puberty onward males have many times the concentration of “male” hormones as females do, with the reverse being true for what are often called “female hormones.” Sometimes, however, hormone levels are abnormal, and females may have an excess of “male hormones” and males may have an excess of “female hormones.”

Gonads Gonads are sex glands that secrete sex hormones. Normally, females have ovaries and males have testes, but as you will read later in this chapter, there are disorders in which assigned sex and the appearance of external genitals do not match the expected gonads.

Internal sex organs Normally, the internal sex organs for the female include the vagina, uterus, and fallopian tubes. For males, the normal internal sex organs include the vas deferens (which transports sperm to the urethra), ejaculatory ducts (which empty into the urethra), urethra (tube that carries urine and semen to outside the body), and prostate gland (which contributes additional fluid to the ejaculate).

External sex organs Normal females have a vulva (external part of female genitals) that includes a number of anatomical structures, such as the labia majora (large flaps of skin, literally “large lips”), labia minora (or “small lips”), and a clitoris, which is a sensitive protrusion covered by a fold of skin. For normal males, external sex organs include the scrotum, which houses the testes, and the penis.

In addition to these biological indicators of one’s sex, there are several other ways that people may be classified as female or male.

Sexual identity Individuals can identify themselves as male or female, regardless of the biological indicators of being male or female. Sexual identity is how someone answers the question of whether they are male or female.

Sex (or gender) role The term “gender” is often reserved for societal manifestations of being male or female—the roles people play—although as noted earlier, I use “sex” as the more inclusive term. Sex (or gender) roles are culturally defined norms for female and male attitudes and behaviors. For example, in most western societies, males do not wear dresses or put bows in their hair. (In some nonwestern societies men wear dress-like clothing.) Similarly, girls may be discouraged from engaging in rough sports such as football. People differ in the extent to which they conform to the gender roles that are prescribed by the society in which they live.

Sex (or gender) of rearing The term “gender” is most commonly used to refer to the psychosocial aspects of rearing. Sex (or gender) of rearing refers to

the way your parents and other socializing agents treated you based on your sex when you were growing up—whether they considered you to be a boy or girl and how they communicated appropriate sex-typed expectations to you. For example, did your parents provide more boy-typical toys such as toy trucks or more girl-typical toys such as baby dolls?

In most instances, all of these criteria for being male or female are in alignment. For example, males have 46XY chromosome patterns, predominately “male hormones,” internal and external sex organs of a male, are reared as boys, and believe that they are boys. But, sometimes, these various indicators are not in agreement. Individuals seeking sex change surgery usually have all of the traditional indicators for their assigned sex, except one—they believe that they were born into the wrong body and should have been born the other sex. Other times, individuals have the external organs of one sex and the internal organs of the other, or they may have external organs that are not concordant with their chromosomes. The question about what makes us female or male may have seemed like a foolish question, but it is often a real dilemma when people decide who is male and who is female. There are even advocates for considering a third option—an intersex option—for individuals who are not clearly male or female on all of these criteria.

THE NOTION OF BIOLOGICAL DETERMINATION

More and more, our society looks to genes to explain . . . even complex social behaviors.

—Wendy McGoodwin, Executive Director, Council
for Responsible Genetics (1998, B8)

The concept of “biological determination” can take a more or less extreme form. A proponent of the extreme form was Sigmund Freud, who is well known for his oft quoted aphorism, “Biology is destiny.” This quote represents the strong form of biological determination or determinism because it implies that, for each of us, our destiny is unavoidably preplanned by biological forces beyond our control. A proponent of the less extreme form of biological determinism would maintain that while biology may underlie some tendencies or make certain experiences more probable, we are not inevitably the products of the biological systems that comprise our bodies. Biology imposes certain limitations on our abilities, but the environment determines the extent to which we develop our abilities. An analogy from health science may help to explain this point. Some people may be born with a biological tendency to become obese; however, with proper exercise and diet they can avoid or postpone this destiny. Similarly, a less extreme form of biological determinism allows for the possibility that females and males may, by self-determination or some

other means, overcome or avoid sex-related biologically based predilections or tendencies to develop certain cognitive abilities; the less extreme form of biological determinism considers the impact of environmental influences on male and female human existence.

Of course, as listed in the last section, there are numerous and obvious biological differences between women and men, but many of these differences are much less pronounced in humans than in any other vertebrates. If we were concerned with sex differences in reproduction instead of cognition, there would be little or no controversy. The different roles that men and women normally play in reproduction are incontrovertible, although new technological possibilities in reproduction, such as cloning, could change even this most basic difference between the sexes. When the issue is cognition, the questions and answers become more difficult. Are the sex-related differences in cognitive ability inherent in the biology of femaleness and maleness? Or, are the biological factors that make you male or female unrelated to the types of cognitive abilities that you develop? Or, perhaps a better way to ask this question is: To what extent are sex-related differences in cognitive abilities tied to the biology that makes us male or female?

The Zeitgeist for John/Joan

Nature is a political strategy of those committed to the status quo of sex differences.

—John Money (1987, p. 14)

Look carefully at the three questions posed at the end of the last paragraph. Each question presupposes a different type of answer—the first is phrased to suggest that biological variables will be critically important, the second suggests an answer that is more heavily weighted toward environmental variables, and the third implies a “how much of each” type answer. Psychological scientists want answers that are supported with strong empirical data and a well-reasoned set of assumptions and beliefs. But, we are not equally open to all sorts of information. There have been different historical periods and social-political contexts where some types of answers were more readily acceptable than others.

A zeitgeist is a philosophical tenor of the times, a bias in the type of information that the members in a society find acceptable. For example, when I was a student, an influential book on the psychobiology of femaleness and maleness was published. It was aptly titled, *Man & Woman, Boy & Girl* (1972). It was written by two leading sex researchers, John Money and Anke Ehrhardt, who described various case studies from the Psychohormonal Institute at Johns Hopkins University. There was one case study that was particularly intriguing. They told of a pair of identical twin boys, one of whom suffered severe injury to his penis during a routine circumcision. The anguished parents took him to

the Psychohormonal Institute for assistance. At that time, penis reconstructive surgery was extremely crude, so after considerable deliberation, they decided to have their son's genitals reconstructed to appear like those of a female. John was 22 months old when the sex-reassignment surgery was done. The process of restructuring genitals to appear more similar to the other sex had never been attempted on someone who had been born with normal genitals. At that time, the surgery had only been performed on hermaphrodite children who were born with ambiguous genitalia (i.e., physicians and others could not clearly tell if the child's genitals were male or female in appearance). Hormone therapy was planned for this child during his adolescence so that he would have the general physical appearance of a girl. In this way, overnight, John became Joan. Of course, their new daughter would not menstruate or be able to have children because she lacked the internal organs of a female, but she would appear female, and it was hoped, would develop into a normal female in all other respects.

At the time the book by Money and Ehrhardt (1972) was published, Joan (we later learned that the twins' real names were Bruce and Brian and it was Bruce who underwent genital reconstruction and was then named Brenda) was described as dressing in frilly dresses and "granny" nightgowns, playing with dolls, and was reported to be adjusting well. Money described Joan's behavior this way: "The child's behavior is so clearly that of an active little girl and so different from the boyish ways of her twin brother." Perhaps, the most intriguing aspect of this case history was the willingness of the academic and medical community to accept the premise that it would be easy to change a normal, healthy boy baby into a girl with surgery on his genitals, castration in infancy (removal of the testes), hormones administered at puberty, and girl-type environmental experiences. The idea that one's sexual identity (belief that we are either a boy or girl) and sex role adjustment (conformity to societal expectations about behaviors that are desirable for boys or girls) depended primarily on social learning and appropriate hormones administered at puberty was consistent with the zeitgeist in America in the late 1960s and early 1970s.

It is interesting to note that John Money, the first author in the 1970s account of his success in changing John to Joan, introduced the use of the word "gender" to refer to nonanatomical differences between men and women (LeVay, 1996). It is to Money's credit that he popularized the idea that there are many differences between females and males that are unrelated to their anatomy, but unfortunately, he also helped to create the "mind-set" that sex-typical societal roles are exclusively the product of one's environment. Despite increasingly strong signs throughout childhood and early adolescence that Joan rejected her assignment as a girl, Money continued to believe that the best course for her was to continue her life as a woman.

There were, however, some sex researchers and others who doubted that any male could so easily be transformed into a female. Milton Diamond and

H. Keith Sigmundson, two researchers who had long believed that the public had been misled with this story, obtained permission to interview John/Joan thirty years later (as described in Hamer & Copeland, 1998). As they suspected, John/Joan had had a very difficult life. She never adjusted to her status as a girl. In childhood, the other children taunted her with cries of “Caveman” because of her gawky way of walking, awkwardness, and propensity for rough play. As planned, she began estrogen therapy at age 12 in order to develop breasts and other female characteristics, a fact that seemed to increase her misery and discomfort with her body. At age 14 and in complete despair, she threatened suicide. Only then did her parents tell her the truth about her medical background. In the last edition of this book, this story had a happy ending, but soon after the last edition was published, we learned that the real life story of John/Joan was quite tragic. Unfortunately, later facts showed that John could not escape the tumultuous, perhaps even hellish, experiences of his early life. As a young adult, he had his breasts surgically removed, surgically added a penis (which was possible with advances in surgery). He changed his name to David, which he chose because of the biblical story of David and Goliath, and began taking male hormones. As a young adult male, David married a woman with three children and appeared to be living a happy life. But as we learned since the last edition of this book was published, David could not escape the psychological traumas of being a boy who was raised as a girl. His marriage failed and, coupled with the untimely death of his twin brother, he suffered from severe depression. Sadly, David committed suicide in May 2004 when he was 38 years old. In his death, he became a tragic reminder of how deeply sexual identity defines who we are. He is now known by his full name, David Reimer (Colapinto, 2000).

A photo of twins Brian and David (pictured as Brenda) is shown in [Figure 4.2](#).

There are important lessons to learn from the tragic life of David Reimer. Most importantly, his gender identity was not shaped by being raised as a girl; biology has a strong effect on whether people identify themselves as male or female. In hindsight, it is difficult to believe that changing the shape of someone’s genitals is all that is needed to change someone’s sex. But, the zeitgeist of the 1960s favored the idea that environmental explanations can account for most sex differences.

Of course, David represents the experience of just one person, and we cannot safely generalize from a single individual. It is possible that his sex change surgery would have been more successful if it had been done closer to birth. He was almost 2 years old at the time of the surgery and children have already developed an understanding about being male or female even by that young age. The most salient message is that so many people were willing to accept the original John/Joan story because it supported the view that we are all born sex-neutral and that, with secondary sex characteristics induced by hormones that were administered at puberty and sex-typical rearing experiences, a male



Figure 4.2 Brian and David (pictured as Brenda). Their smiling faces belie the tragic life of David Reimer. Photo courtesy of the Reimer family.

could easily become a female or vice versa. The present zeitgeist, at the end of the first decade of the 21st century, is far more biologically oriented. I urge all readers to remain open to the information presented in all of the chapters and to consider the way their world view or the larger societal zeitgeist is influencing their willingness to accept or reject experimental findings.

Are Biological Theories Sexist?

Woman is a pair of ovaries with a human being attached, whereas man is a human being furnished with a pair of testes.

—Rudolph Virchow, MD (cited in Fausto-Sterling, 1985, p. 90)

There are numerous sex-related inequalities in contemporary society. As noted in the first chapter, women earn much less than men, spend more time on housework, and comprise the majority of persons living in poverty. Men, on the other hand, often find it difficult to obtain custody of their children following divorce and have been effectively closed out of female-dominated professions such as secretarial work and nursing. The most recent recession in the United States (and other places around the world) has increased unemployment rates in many job categories, but especially hard-hit are those who work in traditionally male-dominated fields like trucking and the building trades, and more women than men are attending and graduating from college. Suppose

researchers conclude that there are biologically-determined sex differences in cognition. Could this conclusion be used to justify the social inequality that exists between women and men or to support sex-differentiated restrictions such as the need for sex-segregated education?

The possibility that biological theories could be used to justify discrimination is chilling. One tacit assumption inherent in this line of reasoning is that, if the truth were known, females would be found to be “less”—less smart, less able, less strong, or less of whatever society values. I called this belief the “women have less” fallacy when it was discussed in earlier chapters. I return to this assumption later in this chapter when I consider the question of monthly fluctuations in sex hormones and cognitive abilities. The data do not support the tacit assumption that women might be found “deficient,” if biological data were examined. As you will see from the data reported here, the results of biological research do not favor either sex. Although differences are reported, they are exactly that. A point that is made in several places throughout this book is that differences are not deficiencies. If we find that society values the traits and skills that are associated with being male and devalues the traits and skills that are associated with being female, then it is time to rethink societal values instead of denying the existence of biologically based male–female differences.

As you read about biological research into cognitive sex differences, recall the discussion about the distinction between research results and the interpretation of research results that appeared in an earlier chapter. As Reinisch, Rosenblum, and Sanders (1987) noted, correlations between biological and behavioral differences may be bidirectional (behaviors affect biology and biology affects behaviors), imperfect within and between people (both biology and behavior vary), and inconsistent across species (there are critical differences between nonhuman mammals and humans). Even if we find biologically-based differences, we are a long way from understanding how they are manifested in an environmental context that provides different rewards for females and males.

Researchers have identified three interrelated biological systems that could be responsible for cognitive sex differences: (1) chromosomal or genetic determinants of sex; (2) differences in the sex hormones secreted from the endocrine glands and other structures; and (3) neuroanatomical differences in the structure, organization, and/or function of the brain. Theories and research on the biological determinants of sex-related cognitive differences have centered on these three biological systems. Like any division in biology, these are not separate systems; genes and hormones presumably operate on behavior via some neurological mechanism, and differences in sex hormones are largely (but not entirely) dependent on genetically coded information. The brain develops in a hormonal milieu, bathed in prenatal hormones that are under the control of genetic codes. In keeping with the biopsychosocial framework introduced in the first chapter, keep in mind the environmental context in which the

biology of maleness and femaleness expresses itself. There are many environmental variables that affect brain structures and the type and quantity of hormones that are excreted into the bloodstream, thus blurring the distinction between biological and environmental variables.

One of the major difficulties in understanding the contribution of each of these biological systems is that in normal individuals they are confounded. Chromosomes determine the type of sex hormones that are secreted, and these hormones influence brain development. Sex hormones also direct the development of the internal reproductive organs and external genitals. Thus, for most people, all of the biological indications of sex are congruent and interdependent. Although these three systems exert influences on each other, one way to comprehend these intricately enmeshed biological systems is by examining each system separately and then putting them back together to understand how they work in concert. Possible genetic and hormonal influences are presented in this chapter. Brain mechanisms and links among these three systems are presented in [Chapter 5](#). The question for research psychologists is whether any or all of these biological sex differences underlie cognitive sex differences, and if so, how much and in what ways.

BEHAVIORAL GENETICS

Genes are like musical instruments. Genes don't determine exactly what music is played—or how well—but they do determine the range of what is possible.

—Dean Hamer and Peter Copeland (1998, p. 12)

Like many other fields of study, psychology is feeling the effects of the explosion of new research and methods in genetics. Investigators in the field of behavior-genetics look for evidence of linkages between genetic information and complex human behaviors. Genetic material is the basic building block of life. Fetal development proceeds under the direction of the genetic information coded in the genes. Whether you were born male or female with black or white skin and blue or brown eyes was determined by the chromosomes and genes that are responsible for your very existence. The traits that you inherited from your ancestors were transmitted via your genes. Genetic information constitutes the “genotype” of an individual, while traits that are expressed are called the “phenotype.” Phenotype is what we see—either in terms of physical appearance or behavior. Phenotype depends on the interaction of genes with environmental influences. The term “gene–environment transaction” is sometimes used to emphasize the fact that most behavioral traits that are expressed depend on the mutual effect of genetic and environmental influences. Researchers use observable characteristics (phenotypes) to infer genetic information (genotypes). There are four research strategies commonly used to study

the influence of genetic information on cognition (adapted from Eliot & Fralley, 1976):

- 1 Examine a large number of people to determine, for example, the proportion of women and men who exhibit good spatial or verbal abilities.
- 2 Look at the heritability pattern of abilities across generations to determine the “pedigree” of cognitive abilities. Researchers utilizing this approach might examine siblings or parents and children to ascertain whether good mathematical or verbal ability tends to run in families.
- 3 Utilize individuals with genetic abnormalities to infer the effect of genetic information in normal individuals. An example of this approach would be to discover if individuals who are genetically male, but appear female, show typical “male” patterns of cognitive abilities.
- 4 Examine monozygotic (“identical”) and dizygotic (“fraternal”) twins to determine the extent to which cognitive abilities are under genetic control. If monozygotic twins are more similar than dizygotic twins, then these results would provide some support for genetic influences on cognitive abilities. This is especially true when researchers are able to compare cognitive abilities for identical twins that were reared apart. In this case, the twins share a common heredity, but have experienced a different environment.

All of these research strategies have been used to understand the role of sex-related genetic factors in the development of cognitive abilities.

Are Females and Males Affected Equally by Heredity?

Heredity refers to the transmission of characteristics from parents to their children via their genes. It is different from heritability, which is an estimate of the variability for some trait in a population. Thus, heritability refers to populations and not individuals. In order to explain sex differences in cognitive abilities with appeals to heredity, it would be necessary to show that heredity varies, in some way, as a function of one’s sex or to establish some other link between one’s sex and the heritability of cognition. Merely knowing that cognition is, in part, inherited will not help in understanding why females and males, on average, show different patterns of cognitive abilities. One possible explanation for sex differences in cognitive abilities is that females and males differ in the extent to which they inherit cognitive abilities.

Consider, for example, a recent study of the heritability in childhood attention deficit disorder (ADD; Freitag, Rohde, Lempp, & Romanos, 2010.) As noted earlier, ADD is much more common in boys so it is a possible condition for sex differences in heritability. As its name implies, it is characterized by problems with attention and often includes hyperactive behavior. A usual

approach to studying heritability is to compare concordance rates (rates of agreement or co-occurrence) among members of the same family (who share partial genetic make-ups and similar environments), adopted siblings (who are dissimilar genetically, but similar in environment), and twins, especially same-sex identical (monozygotic) twins who have the same genetic make-up and similar environments. The results were, not surprisingly, complex and depended on various measurement issues and subtypes of ADD. As with virtually all complex behaviors, multiple genes are involved, but the results for the purposes of this illustration showed that for one subtype of ADD a genetic factor was more common in girls than in boys. These authors are careful to note that family environmental risk factors have also been found, so, as with many studies of the genetic bases of behavior, we must consider both genes and the environment. (Some severe types of mental retardation are virtually independent of environmental effects, but these are special cases.)

Sex-Linked Versus Sex-Limited

Environmental transmission from parent to offspring has little effect on later cognitive development.

—Robert Plomin, David W. Fulker, Robin Corley,
and John C. DeFries (1997, p. 447)

One of the major differences between males and females is the pair of sex chromosomes, which differ markedly from each other in size and shape. Females have two X chromosomes—one is contributed by the biological father and the other by the biological mother during fertilization. The male sex chromosome pair is designated XY. The X is contributed by the biological mother and the Y is contributed by the biological father. The Y chromosome is very small and contains little genetic information except for determining sex (Carter, 1972). In contrast, the X chromosome is relatively large and contains a great deal of genetic information. Characteristics (like whether an individual develops ovaries or testes and certain types of red–green color blindness) that are determined by information coded in the genes on the sex chromosomes are called “sex-linked characteristics.” Such characteristics are tied to the fact that we are born either male or female because they are carried on the chromosomes that determine sex.

In addition to the pair of sex chromosomes, humans have 22 pairs of other chromosomes known as autosomes. Sometimes a characteristic that is coded on an autosome appears predominantly in one sex or the other. Such characteristics are called “sex-limited,” and appear predominantly in one sex because of a multiplicity of genetic influences. The genetic basis for sex-limited traits is the same for both sexes (Jensen, 1998). Pattern baldness, for example, occurs primarily in men and is inherited through genetic information on an autosomal

pair of chromosomes. Even though this type of baldness occurs most frequently in men, the genetic information that causes it is not coded on the sex chromosomes. Thus, we can dispense once and for all with the myth that baldness is genetically passed down to male children by their mothers or mothers' fathers. Baldness results from the genetic contributions of *both* parents. Not all traits that occur only or mostly in one sex are coded on the sex chromosomes. Such characteristics are less intimately tied to genetic determinants of sex than sex-linked characteristics.

Studies have shown that males are more biologically vulnerable from the moment of conception. Researchers estimated that at conception there are 140 males conceived (called 46XY to denote the fact that there are 46 chromosomes with the sex chromosome pair XY) to every 100 females conceived (46XX). The ratio of male:female live births is 107 males born for every 100 females. By age 65, the male:female ratio is 78:100 (Central Intelligence Agency, 2010b). These numbers reflect the fact that fewer male embryos ever make it to birth and, after birth, males die an average of approximately 7 years earlier than females (Coren & Halpern, 1993; Halpern & Coren, 1988, 1991).

Genetic research is progressing at a rapid rate as biomedical sleuths unravel the mystery of the DNA molecule. It is only within the last 25 to 30 years that researchers have located the gene that acts as a switch for maleness "transforming a growing human fetus that otherwise would become a girl into a boy." The gene for maleness is located on the Y chromosome. It becomes operative during the seventh week of pregnancy "setting off a complex biological cascade that turns the fetus's immature sex organs into testes" (Braun, reported in Angier, 1990, p. 3). If this gene is missing (as it is in normal females) the developing organism will be a female. This fact has led some researchers to note that the basic human blueprint is female, although it is probably more accurate to think of female and male genitals as two variations of a common theme. During embryonic development, the internal and external structures go through an "indifferent" stage from which either male or female versions develop.

In thinking about heredity and cognitive sex differences, it is important to have a theory about the structure of intelligence so we can consider how intelligence might be inherited. Do we inherit some global trait that is intelligence or is intelligence made up of many different parts?

Molarity or Modularity?

As explained earlier, psychologists who study human cognition often disagree over whether intelligence is best considered as a single, unitary process—a sort of general intelligence that operates across a variety of cognitive tasks or multiple processes. The unitary view of intelligence is called "molarity." By contrast, when we break general intelligence into different types of abilities,

such as verbal or visuospatial ability, this multi-part view of intelligence is called “modularity.” This distinction is the same as that made in the first chapter of this book where the idea of separate cognitive abilities was discussed. In the context of behavioral genetics, the question is whether general intelligence is inherited—the molar view—or whether separate cognitive abilities are each inherited—the modular view. Look carefully at Figure 4.3, which is adapted from an article by Petrill (1997).

Figure 4.3 shows general intelligence and four separate cognitive abilities—verbal, spatial, speed of processing, and memory. Each of the four cognitive abilities is measured with at least two different tests. This is shown in Figure 4.3 with two arrows pointing from each cognitive ability to boxes labeled “test.” As Petrill concluded in his article on the heritability of cognitive abilities, there is evidence that both general intelligence is inherited and that the separate cognitive abilities are also inherited. Although most of the genetic effects for intelligence are general, there are also some independent genetic influences on each of the four cognitive abilities depicted in Figure 4.3. Thus, behavioral genetics provides evidence for both a general factor for intelligence (molarity) and separate cognitive abilities (modularity).

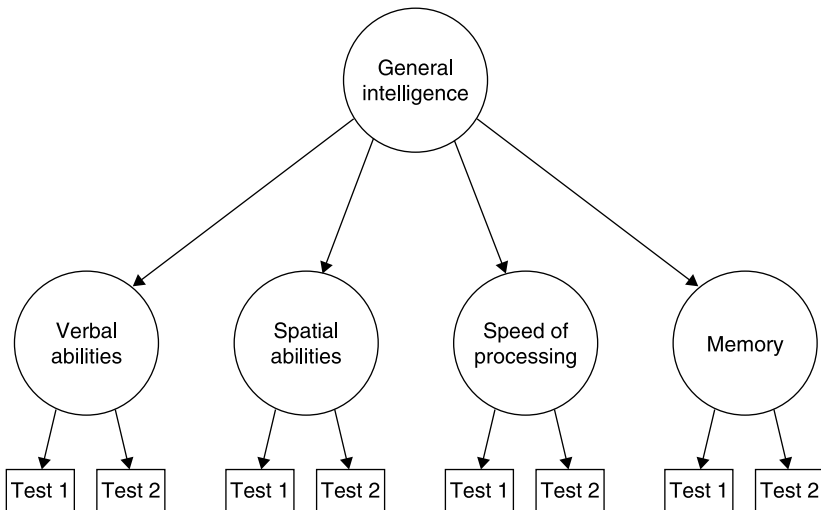


Figure 4.3 Molarity versus modularity. Schematic depiction of general intelligence (molarity) and four separate cognitive abilities (modularity)—verbal ability, spatial ability, processing speed, and memory. The two arrows that are pointing away from the abilities indicate that each ability is measured with two different tests. Petrill (1997) found evidence for heritability for both general intelligence and the four separate cognitive abilities. Figure adapted from Petrill (1997).

Generalist Genes Hypothesis

The importance of genetics for various aspects of human behavior hardly is a matter of discussion any longer.

—Dorret Boomsma, Andrey Anokhin, and Elode de Geus (1997, p. 106)

The idea that most genetic effects for cognitive abilities are general rather than specific is the “generalist genes hypothesis” (Plomin & Kovas, 2005). In other words, some of the genes that affect one cognitive ability, such as reading, also affect other cognitive abilities, such as mathematics, although there would also be some genes that are specific to each ability. In a test of whether mathematics and reading abilities are affected by the same or different genes, researchers identified the lowest 15% of scores from a (very large) sample of 2,596 10-year-old monozygotic and dizygotic twins (Kovas, Haworth, Harlaar, Petrill, Dale, & Plomin, 2007). They concluded that the generalist genes hypothesis was largely correct—the same “generalist” genes affect mathematics and reading disabilities, but as you can probably expect, there are also environmental contributions to reading and mathematics disabilities. As you can also probably anticipate, studies of genetic effects on cognitive abilities can get complex, especially when researchers try to identify which genes are involved. Behavioral genetics is growing increasingly sophisticated as researchers identify small sequences of genes (SNPs, which stands for single nucleotide polymorphisms—pronounced “snips”) and link them to abilities. Recent work using these new genetic procedures has found that there are many genes that influence disability in mathematics and reading, each one generating a small effect across the entire abilities spectrum (Docherty et al., 2010). The take-home message from this complex area of research is that many genes are involved in cognition (possibly thousands), and especially when studying normal cognition (i.e., not disabilities) environmental influences are also important.

More behavioral genetic data have been obtained for measures of intelligence than for any other trait. The whole question of the extent to which intelligence is inherited has been hotly debated throughout the history of psychology and seems no closer to being resolved today than it was over a century ago. The heated controversies generated by the publication of *The Bell Curve* (Herrnstein & Murray, 1994) and the firestorm of vitriolic responses that continues today shows that this topic is as contested during the early decades of the 21st century as it was over 100 years ago. Despite the lack of agreement on the question of how much intelligence is inherited, even staunch environmentalists will agree that it is, at least, partially inherited.

Theories of Genetic Effects on Cognition

Simply stating that genes are important determinants of cognitive abilities or any other trait does not address the topic of sex differences in cognition. Any

genetic explanation of sex differences in any cognitive ability would need to posit an inheritance mechanism that is differentiated by sex. Two prominent theories that associate genes with cognitive sex differences are described in this section.

Sex-Linked Recessive Gene Theory

Genetics is a profound idea. It is an idea that poses disturbing questions and yields disturbing implications.

—Sharon Begley (1999, p. 68)

There are many diseases that are inherited through one of the sex chromosomes (the X or the Y chromosome). A genetic theory of sex differences in visuospatial abilities is based on the assumption that high visuospatial ability is a sex-linked recessive trait that is carried on the X chromosome. (A recessive trait is one that will be expressed, which means that it will appear in a person's phenotype only if both chromosomes carry the gene for the recessive trait or if there is no opposing gene such as would occur if a trait was carried on the X chromosome in males.) If this theory were correct, then females would have a double dose of the genes that determine visuospatial ability because they have two X chromosomes; whereas, males have only one dose and that one always comes from the mother who contributes the X chromosome in her son. For males, their other sex chromosome is the very small Y chromosome, which does not carry any genetic information about visuospatial ability. According to this theory, the "high visuospatial ability" gene is recessive; therefore, this trait will occur more frequently in males than in females because males have no other gene to mask the effects of the recessive gene. Given that females would need to have the "high visuospatial ability" gene on both X chromosomes and males would only need to have it on one, males are therefore more likely to demonstrate good spatial ability. [Table 4.1](#) depicts which individuals would be predicted to demonstrate good spatial ability as a function of their genotype if the sex-linked recessive theory were true.

The beauty of this theory is the explicit quantitative nature of the predictions derived from it. One of the predictions generated from the sex-linked recessive gene theory concerns the total proportion of men and women who would be expected to show good spatial ability. Bock and Kolakowski (1973) estimated that a recessive spatial ability gene should appear with a frequency of approximately 50%. If this were true, then approximately 50% of all men and approximately 25% of all women would be expected to show this trait phenotypically. This prediction can be seen in the male genetic configurations shown in [Table 4.1](#). There are two equally likely male genetic patterns, one of which would be associated with good spatial ability. The 25% prediction for females can also be seen in [Table 4.1](#). There are four equally probable female configurations, only one of which would be associated with good visuospatial

Table 4.1 Predictions derived from the X-linked recessive gene theory of spatial ability

Good spatial ability would be found in:			
1. Hemizygous recessive males (Gene for good spatial ability is carried on the X chromosome)	♂	X ^r	Y
2. Homozygous recessive females (Gene for good spatial ability is carried on both X chromosomes)	♀	X ^r	X ^r
Good spatial ability would not be found in:			
1. Hemizygous dominant males (Gene for poor spatial ability is carried on the X chromosome)	♂	X ^D	Y
2. Heterozygous females (Gene for poor spatial ability is carried on one X chromosome; gene for good spatial ability is carried on the other X chromosome)	{	♀ X ^D	X ^r
		♀ X ^r	X ^D
3. Homozygous recessive females (Gene for poor spatial ability is carried on both X chromosomes)	♀	X ^D	X ^D

r = recessive; D = dominant.

ability. The data, however, do not conform to these proportions. The prediction that half of all males and one-fourth of all females would show this trait phenotypically has not been supported (DeFries, Vandenberg, & McClearn, 1976).

Perhaps one of the biggest problems with the X-linked recessive gene theory is the notion that a complex multidimensional variable like visuospatial ability would have a single genetic determinant. As described in [Chapter 3](#), visuospatial ability is composed of at least five distinct components (mental rotation, spatial perception, visualization, image generation, and spatiotemporal processing). These components are not necessarily related. Genetic theories that fail to make distinctions among these components of spatial ability will never be able to describe adequately the phenomenon. All of the sex-differentiated cognitive abilities are composed of multiple components, and it is unlikely that there is a single gene that controls the expression of any of these abilities. In addition, visuospatial ability is a characteristic that we all exhibit to some degree, a fact that cannot be explained with a single gene.

The X Chromosome and Variability in Intelligence

The subject of sex differences in any aspect of general intelligence is emotionally and politically charged.

—Wendy Johnson, Andrew Carothers,
and Ian J. Deary (2009, p. 598)

A recently proposed theory for the role of the X chromosome in intelligence was designed to explain why males are (usually) more variable on most tests of cognitive abilities (Johnson, Carothers, & Deary, 2009). This theory focuses on the two tails of distributions—those with the lowest scores and those with the highest scores. As the researchers note, there are numerous types of mental retardation that are associated with genes that are located on the X chromosome. These authors explain that they focus on the X chromosome because the Y chromosome is relatively small and carries little genetic information beyond what is needed to cause a developing fetus to be male. Mental retardation can have numerous causes including genetic and environmental, such as lack of oxygen soon after birth or exposure to some toxins. The link to sex differences in cognitive abilities comes from the usual finding that males are more variable in quantitative and visuospatial abilities, and less clearly so, in verbal abilities. As discussed in the following section, two different abnormalities that result from abnormal X chromosomes are associated with several cognitive deficits. The portion of this theory that links the X chromosome to the excess of mentally retarded males is well established (Turkheimer & Halpern, 2009). But, there are no known “intelligence genes” that can explain greater variability at the high end of the distribution. Furthermore, the fact that males and females excel on different cognitive measures defies any X-linked chromosome hypothesis. Thus, it seems clear that the excess of low ability males has a substantial X-linked origin, but the excess of high ability males cannot be attributed to genes on the X chromosome.

Arguing From Genetic Abnormalities

In normal individuals, genetic information and concentrations of sex hormones are confounded. Individuals whose sex chromosomes are XX also appear female, are raised as females, and secrete sex hormones associated with being female. The reverse is, of course, true for males with XY sex chromosome pairs. The problem is isolating the effect of any one of these variables on the cognitive abilities that are differentiated by sex. In order to decide whether men and women tend to excel in different types of intellectual tasks due to genetic programming, the influence of genetic information needs to be disentangled from that of hormones and the large number of life experiences that vary with sex. One way of examining genetic effects is to study people with genetic abnormalities such that the sex hormones and/or external genitals are not consistent with genetic sex.

Turner's Syndrome

There have been many studies of people with genetic anomalies on their sex chromosomes. One such abnormality is Turner's syndrome, which occurs in 1:2,000 to 1:3,000 live births (Lippe, 1991). Instead of the usual pair of X

chromosomes, females with Turner's syndrome have a single X chromosome. This syndrome is designated as 45XO to indicate the fact that they have 45 chromosomes instead of the usual 46 and only one intact X chromosome. The second X chromosome is either missing or seriously defective. Individuals with Turner's syndrome are clearly female in appearance. Their major distinguishing feature is that they tend to be short and will usually require treatment with female hormones in order to exhibit female secondary sex characteristics at puberty. According to the X-linked recessive gene theory, females with Turner's syndrome should display the male pattern of cognitive abilities, that is, on average they should score higher on visuospatial performance tests than verbal ones. The reasoning behind this prediction is straightforward. Like men, they have a single X chromosome, and thus should be more likely to show a recessive X-linked characteristic because there is no other gene to carry the dominant trait. In an early test of this hypothesis, Rovet and Netley (1979) found results opposite to those predicted from this theory. All five of the females they tested had higher verbal scores than visuospatial performance scores, which were substantially below the scores obtained by 46XX (genetically normal) females. (Because individuals with Turner's syndrome are relatively rare, most research with them is done with small samples.)

In a more recent and much larger study of girls with Turner's syndrome, researchers compared the cognitive abilities of girls with Turner's syndrome with those of their unaffected sisters, who served as the control group (Haverkamp, Zerres, Rietz, Noeker, & Ruenger, 2004). Earlier work with Turner's syndrome found mathematics and visuospatial processing difficulties as well as problems with memory. Women with Turner's syndrome typically require treatment with estrogen because they lack the hormones that are associated with normal puberty. The participants in this study were prepubescent and therefore had not yet received hormone treatment. The girls with Turner's syndrome scored significantly lower than their sisters (the control group) on a variety of composite measures of intelligence, including reading understanding, spatial ability, and arithmetic. Thus, their cognitive impairment was not specific to any single type of ability.

Other researchers looked specifically at the ability of girls with Turner's syndrome to process mathematical information (Mazzocco & Hanich, 2010). Deficits in the math abilities for girls with Turner's syndrome can be found as early as kindergarten and continue throughout life. Researchers found that the greatest problem girls with Turner's syndrome had with arithmetic involved timed tests and keeping math information in working memory. Girls with Turner's syndrome may be somewhat below average in verbal abilities, but their math abilities are more seriously affected. This lop-sided pattern of cognitive development has provided support for the hypothesis that prenatal hormones (which are under the direction of genes) affect brain development in sexually differentiated ways, although as with all effects, postnatal environmental differences are also involved.

The Genetics of the Environment

In some instances, the environment reflects rather than affects characteristics of the individual.

—Kimberly J. Saudino (1997, p. 86)

The goal of behavioral genetics is to understand the links between genes and behaviors. The completion of the Human Genome Project, which was an international study of all genetic material, was completed in 2003. It provided a staggering amount of new information about genes, but we still do not have answers to seemingly simple questions such as precisely how many genes humans have. Recent estimates are far lower than estimates prior to sequencing the entire human genome and the number of genes humans possess is now estimated at only 20,000 to 25,000 (Human Genome Project Information, 2008). Even with this new and reduced estimate of the number of genes, the number of potentially related behaviors is virtually limitless, so mapping the way genes affect behavior is an enormous undertaking.

As explained earlier, a commonly used paradigm in human genetics attempts to separate various influences on behavior by comparing identical twins, who are genetically identical, with fraternal twins and non-twin siblings (both are intermediate in their shared genetic inheritance). Comparisons are also made with adopted siblings (dissimilar in genetics, but similar in environment), and twins and siblings who are reared separately from a young age (dissimilar in environment). One consistent and surprising outcome from these various comparisons is that growing up in the same home often makes people different in more ways than if they had grown up in different homes. In other words, the environment is important, but not in the way that most people would predict. Many measures of the environment show genetic influences! Even though two children may have been raised in the same home, each child, to some extent, created her or his own environment based on individual predilections, needs, and desires. This idea may seem paradoxical, after all, the environment does not have DNA (the building blocks of genes), so how can it be affected by genetic factors? It seems that we each select different aspects from the environment. For example, a child with excellent reading abilities might select books from among a large collection of possible play objects (e.g., books, a television, ball, building set) and thereby create an environment that reflects the child's genetic predispositions.

Dickens and Flynn (2001) provided a formal theory of the way aspects in the environment can enhance even small differences, a phenomenon they call the "social multiplier" (p. 347). When twins grow up in the same household, they tend to select different activities as a means of differentiating themselves, but when they grow up in different households, they tend to select more similar activities, ones that are consistent with their biological propensities. According to this point of view, genetic effects can be found in the environment because people with similar abilities and lifestyles select similar environments.

Additional evidence in support of the role of the environment in influencing cognition is found in the “Flynn effect.” Flynn and his colleagues have documented large gains in IQ scores all over the world over the last century (three IQ points per decade; Flynn, 2007; Flynn & Weiss, 2007). The human genome has not changed over the last 100 years, but environments have, so the increase in general intelligence, which reflects increasingly complex environments, is strong evidence for the effects of the environment on intelligence.

The field of behavioral genetics has changed the way we think about the environment, so that it not only reflects genetic influences, it operates prenatally as well. In an article on the importance of environmental variables, Phelps, Davis, and Schartz (1997) reminded researchers that during gestation, the developing fetus is subject to a prenatal environment that can be as critical to development as the genetic program that is orchestrating the creation of a new human. Thus, researchers may attribute an effect to genetics when it is primarily influenced by the prenatal hormone environment. The membrane that surrounds the developing fetus is called the chorion. Some monozygotic (identical) twins share a single chorion; others develop separate chorions. Twins that develop in a single chorion have a more similar prenatal environment than those that develop in separate chorions. Recent studies show that single chorion twins are more similar in intelligence and cognitive abilities than twins with separate chorions (Kim, 2009). Thus, the shared prenatal environment is an important contributor to the trait being measured. The chorion produces hormones (estrogen, progesterone, and others) and thus its action is probably via the effect of these hormones on the developing fetus.

SEX HORMONES

One fact must be kept in mind . . . Humans *are* biological creatures.

—James A. Doyle (1995, p. 45)

A person’s gender, however, is an arbitrary, ever-changing socially constructed set of attributes that are culture specific and culturally generated, beginning with the appearance of the external genitals at birth.

—Ruth Bleier (1991, p. 66)

Mention sex differences with respect to almost any ability and someone is sure to say, “It’s all in the hormones.” Clearly, one of the major biological differences between females and males is the relative concentration of the “female” sex hormones, estrogen and progesterone, and “male” sex hormones or androgens, most notably testosterone. Sex hormones are powerful chemical messengers secreted by the ovaries in women, testes in men, and adrenal glands in both sexes. Because they circulate freely throughout the bloodstream,

sex hormones are able to affect distant target organs, including the brain, muscles, skeleton, and sensory organs.

Despite common misconceptions, it is not true that women have only female hormones and men have only male hormones. Both sexes have measurable quantities of estrogen, progesterone, and testosterone. The relative concentrations of each of these hormones vary by sex and throughout the life cycle. Not only do all normal humans have measurable amounts of all of the hormones that we tend to think of as “female” or “male” hormones, but the body converts these hormones from one chemical configuration to another. Hormonal actions on the human brain are exceedingly complex. Most of the time, before the cells of the brain can use testosterone, it needs to be converted into estradiol, a form of estrogen, which is chiefly a hormonal secretion of the ovaries. More rarely, the brain can use androgens (either testosterone or a different form of androgen “dihydrotestosterone or DHT” directly without the conversion to estradiol) (Collaer & Hines, 1995; Lenroot & Giedd, 2010). “Masculine” hormones not only occur in different forms (metabolites), but the different forms have different effects on development. Additionally, there are different critical periods when hormones have their greatest effect on development, so the development of the genitals in either a female or male direction has a different critical period than the development of different portions of the brain and behavioral traits (e.g., preference for rough and tumble play). Thus, it is very difficult to discern the effects of what we typically think of as female or male hormones because these two types of hormones can be chemically transmuted from one to the other. Additionally, variations in hormone concentrations at different times during prenatal development will lead to different effects. The fact that different forms of testosterone can have different effects means that the differentiation of the genitals in one sex-specific form (e.g., penis for males) does not guarantee that all sex-differentiated aspects will take the same (e.g., male) form.

Some Basic Biology Needed to Understand Hormones

Estrogen rules . . . Estrogen acts on virtually every neuron in the brain.

—Gillian Einstein (neuroscientist, cited in Hopkin, 1998, para. 4)

The hypothalamus is a central structure in the brain. It connects to (or may be thought of as part of) the pituitary gland, which is one of the major endocrine glands in the body. Endocrine glands secrete chemicals, called hormones, directly into the bloodstream. When the pituitary gland receives a signal from the hypothalamus, it releases hormones. Stimulating hormones that trigger activity in other glands are called “tropins.” The pituitary secretes gonadotropins (hormones that trigger gonadal function) that travel through the

bloodstream and cause the ovaries (in women) and testes (in men) to secrete their own hormones. The ovaries secrete a group of hormones called estrogens and the testes secrete a group of hormones called androgens. Testosterone is the most powerful of the androgens. The adrenal glands (which literally means near the kidneys) also secrete smaller amounts of androgens such as testosterone and estrogens as well as other hormones that are associated with responses to stress and regulating sodium in the body.

The endocrine system has numerous feedback loops so when the body is secreting high levels of some hormone, for example testosterone, chemicals will be carried back to the hypothalamus, which in turn will reduce its stimulation on the pituitary to keep the body in homeostasis or balance.

Prenatal and Early Postnatal Hormones

Research on the importance of experience during prenatal life has documented the ability of fetuses to respond to changes in the intrauterine environment, to learn by association of stimuli, and to retain prenatal experiences into postnatal life.

—William P. Smotherman and Scott R. Robinson
(1990, p. 97)

Prenatal hormones are critically important determinants of whether a developing fetus will grow into a male or female infant. The genetic configuration of the sex chromosomes (XX for female, XY for male) determines whether the undifferentiated developing gonads (sex glands) will become ovaries or testes. If they are developing according to a male program, they will begin to differentiate approximately 7 weeks after conception. The newly formed testes will secrete male hormones (primarily testosterone) which, in turn, direct the development of the internal male reproductive organs and external genitals. If, on the other hand, the genetic program is XX, the gonads will develop into ovaries and, in the absence of male hormones, internal female reproductive organs and external female genitals will develop. It is important to note that it is the absence of male hormones, not the presence of female hormones that directs the growth of female organs because in the absence of hormones, or usable hormones, the sexual differentiation of the fetus will be female, although recent research has pointed to a role for estrogen in female prenatal development. Researchers (working with mice) have found that during pregnancy, the uterus, which houses the developing fetus, produces estrogen, which contributes to the maintenance of the pregnancy (Das, Mantena, Kannan, Evans, Bagchi, & Bagchi, 2009). Based on previous work with nonhuman mammals, it seems likely that the uterus is also a source of estrogen in pregnant women. It is also important to keep in mind the fact that the determination of one's sex is composed of a mosaic of factors. Regardless of the genetic sex of a fetus, it can develop the genitals, brain structures, and

behaviors of either a male or female (Collaer & Hines, 1995; Hines & Collaer, 1993).

A schematic diagram of prenatal development is presented in Figure 4.4. It charts the development of females and males from conception until birth. If you read the first edition of this book, you may notice that this figure looks different from its earlier version. Data presented in the following chapter now show that “female” prenatal hormones play a role in the differentiation of the brain, but (probably) not in the differentiation of the genitals (e.g., Berrebi, Fitch, Ralphe, Denenberg, Freidrich, & Denenberg, 1988; Fitch & Denenberg, 1998; McEwen, Alves, Bulloch, & Weiland, 1997). It was formerly believed that these hormones were not important during prenatal development.

There is good evidence to believe that the presence or absence of particular sex hormones during critical stages of postnatal development also plays a role in the sexual differentiation of the developing brain. Hormones for both girls and boys are elevated for the first 6–12 months after birth, and scientists are not sure whether specific brain effects can be traced to prenatal hormones or postnatal hormones within the first year of birth (Eliot, 2009). Thus, it is likely that the hormones that are secreted by the newly formed testes in males, or the absence of these hormones in females, affect the appearance of the genitals,

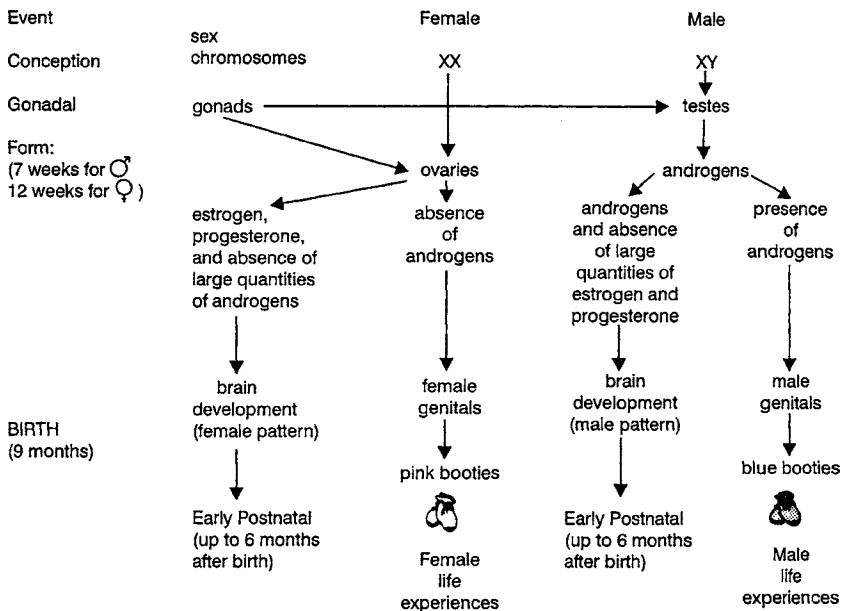


Figure 4.4 Schematic diagram of sex differentiation during prenatal and perinatal development.

but hormones secreted by the testes (in males), ovaries (in females), and adrenal glands (both males and females) direct the development of neural pathways in the newly forming brain.

Approximately 7 weeks after conception, which is when the testes begin secreting androgens, the first fully developed neurons (basic brain cells) begin to form a rudimentary brain. If ovaries are formed, they will develop at approximately 12 weeks, a timing difference that may be important in early brain development. At 28 weeks after conception, “interneurons” form which are essential to the higher level cognitive activities that we consider distinctly human.

The beginning of the second trimester (fourth month of fetal life) is a critical period for brain differentiation (van de Beek, Thijssen, Cohen-Kettenis, van Goozen, & Buitelaar, 2004). Researchers found that measures of testosterone, progesterone (a “female” hormone), and estradiol sampled from the amniotic fluid early in the fourth month of prenatal life predicted sex-typical toy preferences for the infants at 13 months of age (van de Beek, van Goozen, Buitelaar, & Cohen-Kettenis, 2009). Samples of amniotic fluid taken at this critical stage in prenatal brain development show much higher concentrations of testosterone for boys, and higher levels of estradiol for girls, with no sex differences for progesterone levels. Brain development continues at a rapid pace during infancy, and thus is probably influenced by the high levels of gonadal hormones that are secreted in the first 6 months of life. The brain continues to develop throughout the entire life span and is susceptible to the effects of hormones throughout life.

Organizational and Activational Effects

We now know that organizational effects impinge on neural structures and behaviors beyond those related to reproduction. Intuitively, we associate structural differences with differences in physiological and behavioral endpoints.

—Geert J. de Vries and Per Sodersten (2009, p. 592)

Because prenatal and perinatal (around the time of birth) hormones act by directing the formation of the developing brain, some researchers have called these “organizational effects.” By contrast, hormonal effects that occur later in life are sometimes called “activational effects” because they activate neural events, but do not change the structure or organization of the brain or other portions of the central nervous system. Whereas organizational effects were thought to be more long-lasting, hormonal effects later in life were considered more transient, lasting only as long as the hormone is present in the body. Like any dichotomy, it seems that the division of hormone effects into organizational versus activational is not absolute. We now know that brains are far more plastic (malleable) throughout life than earlier researchers had believed

and that hormones and environmental events can permanently alter brain structures in response to changing levels of hormones at adolescence (Lenroot & Giedd, 2010; Schulz, Molenda-Figueira, & Sisk, 2009) and even into very old age (McEwen, 2009).

In order to understand the role that hormones play in shaping biological and psychological indices of sex, it is necessary to isolate experimentally and manipulate sex hormones independent of the other covariates of sex. Two general approaches are used to understand the effect of sex hormones. The quantity and type of sex hormone are manipulated in nonhuman mammals under careful laboratory conditions, and naturally occurring or drug-induced abnormalities in humans are studied. I consider here some of the most relevant research with nonhuman mammals and with humans with hormonal abnormalities. There are strengths and weaknesses associated with each of these approaches.

Laboratory Investigations With Nonhuman Mammals

Much of the experimental research in this area has been performed on nonhuman mammals. While there are numerous biological similarities between nonhuman mammals and humans, one of the major differences is the extent to which hormones direct and control behavior. Hormones are less important in determining behavior for humans than for nonhuman mammals. Thus, while results obtained for nonhuman mammals may be suggestive of possible relationships for humans, they are not directly applicable. Extrapolation from animal data to humans can lead to erroneous conclusions and, for this reason, must be made very carefully.

The majority of the experimental work in this area has been conducted with rats, although other mammals and primates have been used. Prenatal hormones are manipulated in many ways: (a) castrating a developing male; or (b) giving antiandrogens to block androgenic effects, thereby depriving a male of the testosterone secreted by the testes; or (c) removing the ovaries of a developing female rat, thereby depriving her of the hormones secreted by her ovaries; or (d) administering androgens to developing females and/or administering ovarian hormones to developing males; or (e) administering the hormone of interest to the pregnant mother who will pass the hormone on to the developing fetus. Timing of these manipulations is important because there appears to be a critical developmental period for brain differentiation. Research with rodents using these techniques has mapped hormone-sensitive cells in the brain that respond to prenatal sex hormones (McEwen, 1981). In an early review of the literature, MacLusky and Naftolin (1981) cited a number of sex differences in brain morphology that depend on prenatal hormone exposure, including volume differences in certain cell groups and differences in synaptic and dendrite organization. Lewis and Diamond (1995) found that testosterone can have asymmetrical effects on the developing brains of prenatal female and

male rats. When additional testosterone was supplied, male rats showed increases in the thickness of their right hemisphere, whereas female rats showed increases in the thickness of their left hemispheres. I will return to the possibility that female and male humans differ in the way their hemispheres are specialized for different tasks in the next chapter, in which I discuss sex differences in brain structure and function.

Research with rodents, other nonhuman mammals, and humans clearly shows that prenatal and early postnatal hormones influence a wide variety of sex-typed behaviors including activity levels, aggression, roughness of juvenile play, sexual behaviors, maze performance (a spatial skill), and visual discrimination learning (e.g., Grisham, Kerchner, & Ward, 1991; Hines & Sandberg, 1996; Williams & Meck, 1991). For example, control rats that were not operated on and rats whose gonads were removed, but then received testosterone, showed increased exploration of novel objects (which presumably reflects memory because they need to recognize when an object was not seen before). Other rats whose gonads were removed but did not receive supplemental testosterone explored familiar and novel objects equally (Aubele, Kaufman, Montalant, & Kritzer, 2008).

There is also strong evidence from research with rodents that hormones have an important effect on memory in aging animals. For example, Markham, Pych, and Juraska (2002) found that female rats who were deprived of estrogen because they had their ovaries removed showed better memory (in a water maze test) when their estrogen was replaced than control rodents which did not receive replacement hormones. Research findings like this suggest that human females would also benefit from estrogen replacement after menopause when natural levels are low. As readers will soon read, it is likely that the use of hormones for cognitive improvements is more complicated in humans. It can be difficult to see the immediate relevance of research with nonhuman animals, but the underlying rationale is that we are all part of an evolutionary process and experiments that are not possible with humans (for obvious ethical reasons) can be conducted with rats and other nonhuman mammals. It is through research with rodents that investigators learned that estradiol, a hormone that is normally secreted by the ovaries, has a masculinizing effect on behavior. For example, when estradiol is administered to rodents, maze performance improves. To understand how this occurs in normal rodents, recall that testosterone, secreted in large quantities from the testes, is converted into estradiol that activates neural estrogen receptors in the brain to induce masculine-type development. This series of events is depicted in [Figure 4.5](#).

Of course, hormone manipulations are unethical for human subjects. But, in at least one study, researchers were able to persuade Institutional Review Boards (IRBs) that it was safe to administer a single dose of testosterone to women in a double-blind, placebo-controlled, cross-over study (Aleman, Bronk, Kessels, Koppeschaar, & van Honk, 2004). “Double-blind” means that neither the participants nor the researchers who collected the data knew who

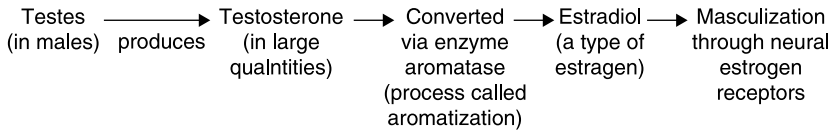


Figure 4.5 How estradiol (an estrogen) masculinizes behavior. Testosterone, which is secreted in large quantities in males by their testes, is converted (the technical term is *aromatized*) into estradiol by an enzyme so that it can be used by the brain. It is estradiol, converted from testosterone, that underlies many male-typical behaviors.

was in the experimental treatment group or who was in the control group. “Placebo-controlled” means that the control group received a similar treatment as the experimental group except that instead of being injected with testosterone, they were injected with an inert substance that would not affect cognition. Finally, the term “cross-over study” means that some participants first received the testosterone and then the placebo and other participants first received the placebo and then the testosterone. The participants who received testosterone showed significantly better performance on a three-dimensional version of the mental rotation test than those who did not (all the participants were women). These are very powerful results that raise several ethical questions that will be addressed in the final chapter. For example, if women achieve higher visuospatial scores after just one injection of testosterone, then is it ethical to allow women (or men) to inject testosterone prior to taking high stakes examinations such as the SATs or Graduate Record Examinations or perhaps surgeons prior to performing delicate surgery or pilots making a difficult air plane maneuver? Rapid advances in the biological underpinnings of cognition raise many new ethical questions.

Theories Relating Sex Hormones to Cognitive Abilities

Four theories (or theoretical approaches) about the relationship between hormone levels and cognition have spurred much of the research in this area. Theories are important because they provide the explanation or answer to questions about why cognitive abilities may be dependent on sex hormones or why some seemingly strange relationships among variables would make sense.

Geschwind–Galaburda Theory of Prenatal Hormones Effects

Norman Geschwind was an early pioneer in the study of hormone effects on behavior, a field that is called “behavioral neurology.” An influential theory

proposed by Geschwind and his colleagues, most notably Galaburda, is based on the underlying assumption that prenatal hormones have a pervasive effect on cognition (e.g., Geschwind, 1983, 1984; Geschwind & Galaburda, 1987). This theory posits that the prenatal sex hormones that both direct and reflect the sexual differentiation of the fetus also exert powerful influences on the central nervous system of developing organisms. In humans, the right hemisphere (half of the brain) normally develops at a faster rate than the left. Because of this differential rate of development, the left hemisphere is at risk for possible negative effects for a longer period of time than the right, and therefore is more likely to be affected by an adverse intrauterine environment. Proponents of this theory assert that high levels of testosterone slow the growth of neurons in the left hemisphere. The result is right hemisphere dominance, which means that the right hemisphere has greater control than the left hemisphere for many cognitive and motor functions.

One index of hemisphere dominance is handedness, that is, whether an individual is right- or left-handed. Because the right hemisphere coordinates movement for the left half of the body and the left hemisphere coordinates movement for the right half of the body, a right-hander is (usually) left-hemisphere dominant and a left-hander is (often) right-hemisphere dominant. (People with mixed hand use, performing some tasks with the right and others with the left, are usually considered as left-handers.) If high levels of prenatal androgen slow neuronal growth in the left hemisphere, as proposed, the result would be right hemisphere dominance, which is manifested in left-handedness. (For an extensive review of the literature on left-handedness, see Papadatou-Pastou, Martin, Munafo, & Jones, 2008.)

There are three sources of prenatal testosterone: (1) maternally produced testosterone that comes from the maternal ovaries, adrenals, and other structures such as fat, (2) adrenal glands in both female and male fetuses, and (3) for male fetuses, testosterone produced by their own developing testes. Thus, normal males are exposed to higher levels of prenatal testosterone than normal females. As would be predicted by this theory, numerous studies have found a higher proportion of left-handedness in males than in females (Halpern, Haviland, & Killian, 1998). For example, a recent investigation found sex differences in left-handedness in Scandinavian countries, with male-to-female odds ratios at 1.34, which means that for every 100 left-handed women, there are 134 left-handed men (Vuoksima & Kaprio, 2010). Similar ratios have been reported in recent meta-analyses of this literature (Papadatou-Pastou et al., 2008). It is interesting to note that women who are also exposed to abnormally high levels of prenatal androgens because of adrenal abnormalities also show higher proportions of left-handedness than other females, as predicted from this theory (Resnick, Berenbaum, Gottesman, & Bouchard, 1986).

An important corollary of the sex hormone hypothesis is that other susceptible organs in the developing fetus are also affected by high testosterone levels. One such organ is the thymus gland, which is an essential component of

the developing immune system. The simultaneous effect of testosterone on the development of the left hemisphere and the thymus and other organs results in the prediction that there would be a greater incidence of immune disorders among left-handed individuals. The first evidence for this relationship came from Geschwind and Behan (1982, 1984). They showed that autoimmune diseases (especially those involving the intestinal tract and the thyroid gland) and atopic diseases (allergies, asthma, eczema, and hay fever) are 2.5 times more frequent in strong left-handers as in strong right-handers. These results have been essentially confirmed in several subsequent studies. (See Bryden, McManus, & Bulman-Fleming, 1994, for a critique and review of this theory.)

If, as this theory predicts, left-handedness is sometimes the result of exposure to higher than average amounts of prenatal testosterone, then we would expect a positive association among being male, being left-handed, immune disorders, and patterns of cognitive abilities that are known to be lateralized (or specialized) in the right or left hemisphere. There are at least two possibilities:

- 1 overall poorer performance by males on cognitive tasks that are usually associated with the left hemisphere, which generally includes verbal tasks and/or
- 2 overall higher performance by males on cognitive tasks that are believed to be primarily under right hemisphere control, which generally includes visuospatial tasks.

As you know from the previous chapter, males tend to excel at some visuospatial tasks and some mathematical reasoning tasks, most notably tasks that require mental manipulations of spatial information and the mathematics section of the SATs. These are both associated with right hemisphere functioning. Males also have a majority of the language production and reading problems. In addition, there is a relationship between left-handedness (more accurately non-right-handedness), asthma, and other allergies (Andreou, Krommydas, Gourgoulanis, Karapetsas, & Molyvdas, 2002), thus confirming, in a general way, some of the theoretical predictions. Geschwind and Galaburda's theory is summarized in [Table 4.2](#).

Finger Length and Prenatal Testosterone 2D:4D Ratios

The Geschwind–Galaburda theory links handedness (being right- or left-handed) with prenatal testosterone. A more recent theory proposed by Manning (2002) relates prenatal testosterone and estrogen to the relative length of the index (second) finger and ring (fourth) finger, a theory that actually dates back at least 100 years (reviewed by Peters, Mackenzie, & Bryden, 2002). This theory is known as 2D:4D ratio. The underlying idea is that both limb and genital development are regulated by the same “family” of genes. Manning

Table 4.2 Summary of Geschwind and Galaburda's theory

Relationship among:	Sex, handedness, immune disorders, and cognitive abilities
Theory:	High levels of prenatal testosterone slow neuronal growth in the left hemisphere and diminish the size of the developing thymus gland
Predictions:	Positive associations among: Being male Being left-handed Immune disorders (e.g., allergies) Anomalous right-hemisphere cognitive abilities (e.g., mathematical giftedness, some types of retardation)

proposed that a large ratio reflects lower levels of prenatal testosterone and higher levels of prenatal estrogen. To calculate your own 2D:4D ratio, take a photocopy of your right hand (some measures use both hands, but the more usual measure is with the right hand) and then use the photocopied image to measure the distance between the crease where your finger meets your palm for your second and fourth finger, then divide the length of your second finger by the length of your fourth finger. Of course there is considerable variability, so do not be concerned if your own measurements do not conform to the usual findings. In general, men's index fingers tend to be shorter than their ring fingers, whereas women's index and ring fingers tend to be either more similar in size or their index finger is slightly longer than their ring finger. If you compute the ratio of the length of a person's index finger to the length of their ring finger, men will have smaller ratios than women will. The ratio for women will be close to or greater than 1.0. This sex-differentiated pattern of digit ratios holds up even though men tend to have larger fingers than women have. The male pattern of digit ratios supposedly reflects higher levels of prenatal testosterone.

Figure 4.6 shows how to measure the length of the second and fourth digits using measuring tubes. After measuring your own second and fourth finger, compute the ratio by dividing the value you measured for your second digit by the value you measured for your fourth digit.

With such an easy and nonintrusive measure of fetal hormones, you might guess that these findings have stimulated a large number of studies, which is exactly what happened. The research literature on 2D:4D ratios is so huge that I can only sample a few studies for this chapter. Keep in mind the general rationale for studying 2D:4D ratios. The size of the ratio reflects prenatal hormones, so if there are differences on cognitive tasks or other variables of interest, such as sexual orientation, then there is a link between prenatal hormones and whatever behavior or trait that is being studied. It is also possible that digit ratios are influenced by hormone levels at puberty as well as prenatal hormone levels (Lippa, 2006).

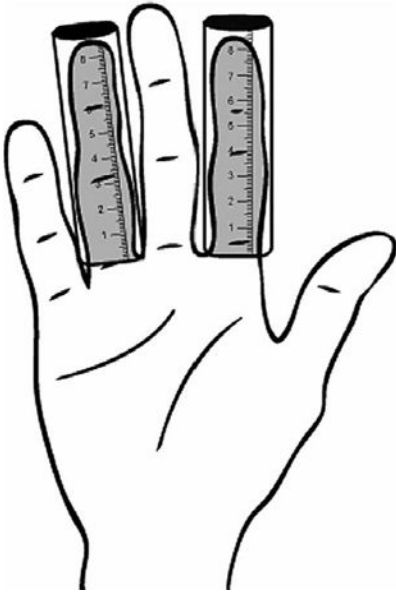


Figure 4.6 A new means of measuring index/ring finger (2D:4D) ratio and its association with gender and hand preference. From Nicholls, Orr, Yates, and Loftus (2008). Reprinted with permission of Taylor & Francis.

Digit Ratios and Cognitive Abilities

In both sexes, better visuospatial performance was associated with lower (more male-typical) digit ratios.

Marcia L. Collaer, Stian Reimers, and
John T. Manning (2007, p. 177)

In the previous chapter, I discussed studies that collected data from hundreds of thousands of people on an internet site that was sponsored by the British Broadcasting Corporation (BBC). One of those studies involved making judgments of line orientation. Very large effects were found favoring males on this task (Collaer et al., 2007). In the same study, respondents also reported the length of their second and fourth fingers. The researchers found that, in general, women had higher finger ratios than men, but when they looked at people who performed well on this task, regardless of sex, better performance was correlated with the male-typical pattern of lower digit ratios. These results suggest that higher levels of prenatal testosterone and/or lower levels of prenatal estrogen are associated with better performance on a visuospatial task in which respondents make judgments about the orientation of lines.

There are many other studies that relate 2D:4D ratios to cognitive tasks. In one study, university women were tested on their ability to find a platform in a simulated water maze (Csatho, Osvath, Karadi, Bicsak, Manning, & Kallai, 2003). Water mazes are commonly used to study navigation with nonhuman mammals, most often rats. A rat is put into a tub of cloudy water and has to find its way to a platform that offers safety. There are several adaptations of this paradigm for humans, including the one used in this study in which participants wore opaque goggles to simulate what rats would see in a cloudy water maze. In this study, participants with lower 2D:4D ratios took less time in finding the platform and had better spatial memory.

If higher levels of prenatal testosterone lead to increases in left-handedness and smaller 2D:4D ratios, you may be wondering whether left-handedness is associated with lower digit ratios? The answer is yes. Researchers in Austria associated finger length ratios with a large number of biological and psychological variables in a sample of firefighters (Voracek, Pum, & Dressler, 2010). Replicating other studies cited in their research report, they found an increase in left-handedness was associated with lower 2D:4D ratios. They also found that this male-typical pattern was also associated with sensation-seeking and other traits that might be expected of firefighters, but as a group, the firefighters did not differ in their digit ratios from other samples of males. The authors conclude that a basic sex difference in 2D:4D ratios is determined in utero and it is an indirect marker of the organizational effects of prenatal hormones.

The very large BBC internet study provides strong evidence for a relationship between handedness and 2D:4D ratios. Studies that involve handedness need to have very large samples because only a small percentage of the population is left-handed (approximately 10%), so a very large sample is needed to be sure to include enough left-handers to investigate any variable that might be associated with handedness. The large internet study was able to collect data from hundreds of thousands of individuals, which means that it can “pick up” effects that are small in size (small differences between groups), but may be important. Manning and Peters (2009) found a smaller ratio among left-handers (more male-typical) than among right-handers. Like the Geschwind and Galaburda theory, the focus is on the effects of prenatal hormones. The difference between these two theories is the use of finger length ratios to assess the effect. This is a rapidly evolving area of research and, because it is so easy to measure handedness and digit ratios, I expect the topic of handedness, finger ratios, and sex differences to be a “hot” research area over the next decade.

Optimal Level of Hormone Theories

A third theory that relates sex hormones to cognitive abilities was proposed by Nyborg (1984, 1988, 1990), although numerous other researchers have suggested similar theories. Nyborg’s model is called the “general trait covariance–androgen/estrogen balance model.” (Quite a mouthful! I don’t know why

they can't give these models simple names like "Fred.") This model is based on the assumption that there is a range of hormone levels that yields optimal expression of spatial ability. Nyborg targets estradiol as the critical hormone, although other researchers have posited an optimal level of testosterone as the critical hormone for various cognitive abilities.

Recall that androgens can be chemically converted (the correct term for this is "aromatized") to estradiol for use by the brain. According to Nyborg, it is estradiol, a hormone that is stereotypically thought of as a "female" hormone (but we know better—it is found in both males and females), that is consequential in the expression of spatial abilities. Nyborg's model is depicted in Figure 4.7.

Look carefully at Figure 4.7. As you can see, the central portion of the inverted "U-shaped" curve represents the optimal concentration of estradiol for spatial ability. In general, females will have greater amounts of estradiol (more than the optimal amount) and males will tend to have smaller amounts of estradiol (less than the optimal amount). According to this theory, males who are more "feminized" and females who are more "masculinized" will have better spatial skills. If you look closely at Figure 4.7, you'll see that the left-hand portion of the curve represents low levels of estradiol. When the concentration of estradiol is raised in women who had extremely low levels of prenatal hormones (for example, females with Turner's syndrome, the genetic

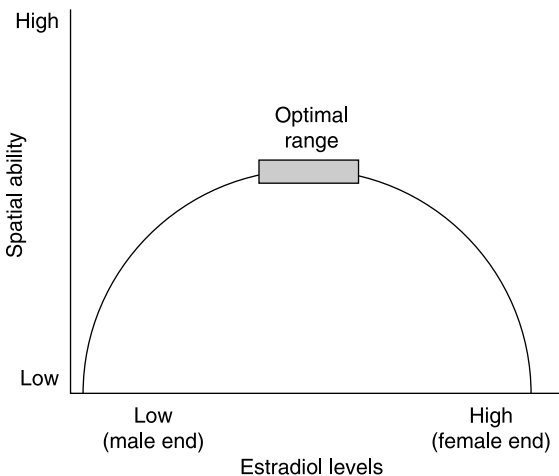


Figure 4.7 Graphic depiction of Nyborg's (1990) model, which posits that there is an optimal range of estradiol that is needed for the expression of spatial abilities. Note that most males are relatively low on estradiol and most females are relatively high on estradiol. According to this theory, increasing estradiol for most males and decreasing estradiol for most females will improve their spatial abilities.

abnormality noted as 45XO), they move closer to the middle portion of the curve (Nyborg, 1983).

There has been some support for Nyborg's general notion of an inverted "U-shaped" relationship between estradiol or its precursor testosterone and spatial ability, but the data are still open to alternative interpretations. Tan and Tan (1998) found a curvilinear relationship between testosterone (measured in blood samples) and performance on a spatial test of intelligence known as the Catell Culture Fair Intelligence Test. As reported elsewhere, there were no overall sex differences on this measure of intelligence. Of course, there were large differences between the women and men in the total amount of testosterone found in their blood, but the same inverted "U" function applied for both sexes.

The idea that there exists some optimal level of a hormone such that too much or too little is associated with poor performance on cognitive tests is popular, especially in the literature on aging cognition. For example, Matousek and Sherwin (2010) gave older men a comprehensive battery of tests that included tests of mental rotation, the water-level test, paper folding, verbal ability, verbal memory digit-symbol copying, and many others that were described in [Chapter 3](#). They also measured testosterone and estradiol levels in their sample of older men. The researchers found a curvilinear relationship between working memory and two measures of testosterone, which provides (partial) support for the idea that there is an optimal level of testosterone, at least for some cognitive tasks. The researchers failed to find any relationship with estradiol, but the researchers noted that many of the older men in their sample had very low levels of testosterone and estradiol, a fact that would make it more difficult to find relationships between hormone levels and performance on cognitive tests. Other researchers have confirmed the curvilinear relationship between levels of testosterone and memory and speed of mental processing, using a broader age range of men (Muller, Aleman, Grobbee, de Haan, & van der Schouw, 2005). Thus, these results have, in general, been replicated several times.

Because of dramatic age-dependent fluctuations in hormone levels, it seems likely that the influence of these hormones would also vary with age. In fact, many cognitive abilities, especially spatial abilities, decline as adults age. There are many possible reasons for the age-related decline, but drops in testosterone and estradiol are likely to be part of the reason.

Pregnant Women

The work reflects the simple fact that mothers are different from non-mothers.

—Craig Howard Kinsley (2008, p. 4)

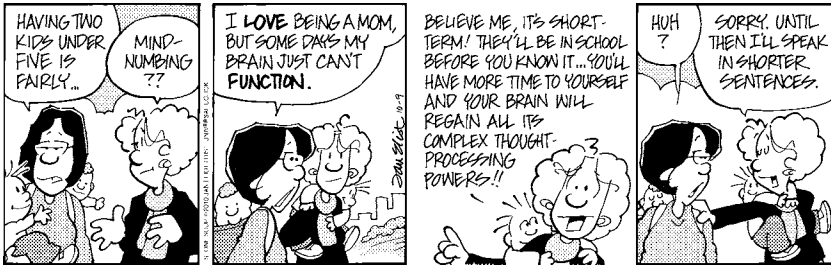
If higher levels of androgens are associated with better visuospatial performance in women, then this effect should be found when women have higher than normal levels of androgens. This occurs naturally when women are

pregnant with boys, but not when they are pregnant with girls. Recall that the developing testes in male fetuses secrete androgens, and some of these androgens circulate in the mother's bloodstream. Thus, one prediction is that women who are pregnant with boys will have better visuospatial skills than women who are pregnant with girls. In one study that tracked the cognitive performance of women throughout their pregnancy and beyond, the researchers found that the sex of the fetus only affected difficult tests of working memory and mental rotation (Vanston & Watson, 2005). These results were found even though the women did not know the sex of their baby before birth. So, the results were in the predicted direction, but small in size and seem limited to specific tests of cognitive abilities and need to be replicated several times before strong conclusions can be made.

Other studies of cognition in pregnant women did not control for the sex of the developing fetus and when differences were found they were usually in the direction of lower ability relative to age- and education-matched nonpregnant controls. For example, one study examined pregnant and nonpregnant women using a battery of neurocognitive tests (de Groot, Vuurman, Hornstra, & Jolles, 2006). The researchers tested the women at four different times through pregnancy (weeks 14, 17, 29, and 36) and then at 32 weeks postpartum. They found that general speed of processing and learning and remembering words was impaired for the pregnant women. Many women joke about their pregnant brain, and it seems that there may be some cognitive detriments, although it is also possible that the pregnant women were feeling nauseated or overwhelmed at the work needed to prepare for a new baby or there was some other third variable that was responsible for these results.

Studies of the effects of pregnancy on the brain have most often relied on nonhuman mammals. These studies usually find that mothers demonstrate cognitive enhancements relative to non-mothers, including better memory (Kinsley, 2008). The underlying idea is that the maternal brain needs to meet the demands of caring for the offspring, protecting them from threats, and being efficient at acquiring food. So, it would follow that the brains of mothers would be enhanced because of these extra demands.

Considered together, the research literature on the brains of mothers suggests that some of the benefit for mothers may arise from the extra testosterone that comes from carrying male fetuses. Nonhuman mammals often have large litters, which makes it likely that they will be carrying some males, so perhaps that is why research with nonhuman mammals is more likely to find beneficial effects of pregnancy. But, if evolutionary theories were relied upon, then there should also be an advantage when the fetus is female because the same demands for finding food and protecting offspring would apply. It is surprising how little research addresses the questions about the maternal brain. I hope that readers can generate many possible hypotheses for studies of maternal brains, and perhaps some of you will conduct the research that is needed to find clearer answers.



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Other (Opposite)-Sex Twins

Another normally occurring situation in which females are exposed to higher than average levels of androgens is in other-sex twins. The girl twin would be exposed to some of the circulating androgens in utero that are produced by her twin brother. One prediction is that girls with male twin brothers would show better cognitive performance on those tasks that tend to favor boys. This hypothesis has been studied in nonhumans that have large mixed-sex litters such as gerbils and rats (e.g., Clark, vom Saal, & Galef, 1992). The general finding with large mixed-sex litters is that being positioned between male siblings during prenatal development influences the female's behavior in a male-typical direction. But, research with human other (opposite)-sex twins suggests that the effect is limited to some, but not all tasks where males usually show an advantage. For example, in a twin study of high achieving children in mathematics, the researchers found the environmental and genetic effects for high achieving children to be similar to that found across the entire range of mathematics achievement (Petrill, Kovas, Hart, Thompson, & Plomin, 2009). Or, in other words, the hypothesis that girls with twin brothers would show exceptionally good math achievement was not supported. Recall that there is little difference between males and females on most tests of mathematics—differences emerge as the sample becomes more selective. So, it is not surprising that girls with male co-twins do not differ from other girls in mathematics since there is little difference overall on most tests of mathematics, which in turn means that very large samples would be needed to find statistically significant differences.

On the other hand, it seems that when females have a male co-twin, they score significantly higher on the mental rotation test than a control group of girls with girl co-twins (Vuoksima et al., 2010). Researchers studied 804 twins; some had same-sex twins (two girls or two boys); others had twins of the other sex (girl–boy twins). The researchers noted that the improved performance of girls with boy co-twins relative to girls with girl co-twins could be

due to the likelihood that girls with brothers who are close in age are more likely to engage in more male-typical play behavior and have typical male toys, such as trucks and wooden blocks, for play. Thus, it is possible that some or all of the advantage for girls with twin brothers is environmental; prenatal hormones most likely play some role given confirming data from other animal species.

You may be wondering if there is other evidence that having a male co-twin masculinizes females in some physical way. Some studies have found a more masculine pattern of second to fourth finger ratios in girls with male twins (van Anders, Vernon, & Wilbur, 2006). So it is likely that exposure to excess testosterone during prenatal development affects brain development.

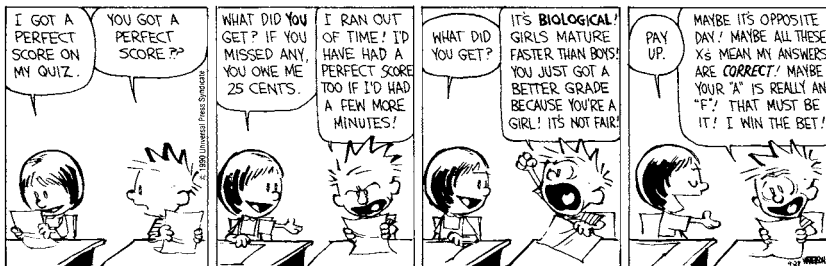
Age at Puberty: Do Early Maturers Have an Intelligence Advantage?

In the 1960s Tanner (1962) suggested the possibility that growth spurts in physical height are associated with spurts in mental ability. If this were true, then there would be an intelligence advantage for children who mature at a young age because they would have enhanced intellectual capabilities at a younger age than their peers. Newcombe and Dubas (1987) conducted a meta-analytic review of the literature that pertained to this question. They found a small but reliable advantage in IQ for early maturers before, during, and after puberty. The extended line of reasoning is that because girls mature earlier than boys, girls have a “maturation advantage” that could explain the finding that girls outperform boys in early language-related skills. The major problem with this hypothesis is that the underlying cognitive mechanisms that vary as a function of maturation are unspecified, making this a weak theory. It also requires two assumptions: (1) verbal abilities rely on different biological mechanisms than spatial abilities, and (2) it is only verbal abilities that primarily benefit from early maturation.

A second hypothesis that links sex-related cognitive patterns to the rate of maturation posits that sex-differentiated cognitive patterns are a by-product of sex differences in maturation rate at puberty. Waber (1976, 1977), a proponent of this theory, found that later maturing adolescents, regardless of sex, exhibited better spatial skills than earlier maturing adolescents of the same age. (Waber measured maturation by the development of secondary sex characteristics during a well child physical examination conducted in a nurse’s office. There are numerous problems with such a subjective measure.) Thus, in general, late maturers have higher spatial skills than verbal skills and early maturers have higher verbal skills than spatial skills. The fact that girls generally attain physical maturation earlier than boys could explain cognitive sex differences. Thus, according to this view, the same hormonal events that are responsible for the timing of puberty are also responsible for sex-differentiated patterns of cognitive differences. The idea that cognition could be predicted by

the age at which an individual experiences puberty was appealing for several reasons. Most importantly, Waber linked this theory to developmental differences in brain organization (a topic discussed in the next chapter), which gave this theory a solid grounding in biology. Sanders and Soares (1986) investigated the age at puberty hypothesis with a sample of college students. The students responded to a series of questions about the timing of puberty events, which is a problematic way to measure the onset of puberty because of the vagaries of memory and problems with self-report data. The students used a 5-point scale to indicate, relative to others of the same sex, when they experienced several milestones of puberty such as menstruation (for females), nocturnal emission (for males), underarm hair growth, etc. They found that college students' scores on a mental rotation test were significantly related to their reports of when they reached puberty. As predicted by Waber's "age at puberty" hypothesis, late maturers of both sexes had higher scores on a mental rotation test than early maturers.

The idea that the age at which one reaches puberty is associated with cognitive abilities has not generated much research in the last decade, in part because there were many studies that failed to find the hypothesized effect. Two different literature reviews (Newcombe & Dubas, 1987; Signorella & Jamison, 1986) concluded that the association between spatial ability and age at puberty is small; others concluded that there is *no* association between spatial ability and timing of puberty (Geary, 1988). A recent study found that age at puberty had small but important effects on cognition when the researchers also measured handedness (Sappington & Topolski, 2005). Researchers used SAT-M scores for 500 undergraduates. As readers will recall, the SAT-M shows average higher scores for males (as described in [Chapter 3](#)). College students reported the age at which they attained puberty, which is usually the age at which women had their first menstrual period, and for men it is usually their first seminal emission or age at which pubic hair developed. They divided respondents into groups of "early" puberty, which was younger than 12 years of age, "middle," which included 12 up to 14 years of age, and "older," which included ages older



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than 14. Men had higher scores than women, as expected, but scores on the SAT-M were particularly high for left-handed men and women who also reported an early age of puberty. The authors hypothesize that left-handedness is a marker for higher levels of prenatal testosterone and an early age of puberty means that these young adults had a higher lifetime exposure to higher levels of hormones. I return to the lifetime hypothesis later in this chapter.

As you will read in [Chapter 6](#), there are good reasons to believe that psychosocial events that occur at puberty (such as choice of preteen activities) play a more important role in the development of many cognitive skills. Furthermore, it is difficult to tease apart hormonal and genetic influences. The timing of puberty is under genetic control. It begins as a brain event with the release of a hormone (gonadotropin-releasing hormone) from the hypothalamus. Thus, genes, hormones, and brain activity work in concert to make each of us the unique beings that we are.

In summary, four theories have been proposed to explain the effect of sex hormones on the development of cognitive abilities. I have summarized these theories in [Table 4.3](#) for review and ease of comparison.

Arguing From Hormonal Abnormalities

There are many clinical syndromes in humans that result from abnormalities in the prenatal hormone environment. These “accidents of nature” allow us to examine the way different hormones act prenatally for humans. As already noted, in general, findings from experiments with nonhuman mammals and with people with abnormal prenatal hormones corroborate each other and extend what we are able to learn from people with normal hormone levels.

Fetal Androgenization

What are the effects of high levels of male hormones on a developing fetus? This question has been answered with two different groups of people who were exposed to abnormally high levels of androgens during fetal development.

CAH A medical condition that exposes developing fetuses to extremely high levels of androgens is congenital adrenal hyperplasia (CAH, also known as androgenital syndrome or AGS). CAH is a genetic recessive disorder in which the adrenal glands produce abnormally high amounts of androgens beginning in the third month of fetal life (Nyborg, 1983). When the genetic pattern for the developing organism is female (XX), she is exposed to abnormally high levels of prenatal androgen compared to a normal female; when the genetic pattern is male (XY), he is exposed to elevated levels of prenatal androgen, more than a normal boy, but it is not as massive a change as it is for a girl with CAH (Newcombe & Baenninger, 1989).

Table 4.3 Summary of theories designed to explain the effects of sex hormones on cognitive abilities

1. Geschwind–Galaburda theory of prenatal hormones effects

High levels of prenatal testosterone slow the growth of neurons in the left cerebral hemisphere, which results in increased left-handedness (reflecting the dominance of the right hemisphere).

Data in support of theory: There is a greater incidence of left-handedness among males than females and an association between left-handedness and tasks associated with right hemisphere function such as (higher level) math and visuospatial skills.

2. Finger length and prenatal testosterone 2D:4D ratios

Prenatal hormone levels affect brain development and relative growth of the fingers because both are under the control of same “family” of genes. Ratios of the length of the index finger to the ring finger are higher for women (more similar in length so close to or slightly greater than 1.0) than men’s finger ratios.

Data in support of theory: Many studies found a relationship between a male ratio pattern and better performance on visuospatial tasks (for both women and men).

Taken together, the Geschwind–Galaburda theory and finger length theory predict more left-handedness among people with a male pattern of finger ratios, which has been confirmed.

3. Optimal level of hormone theories

The relationship between hormone levels (estradiol and testosterone) and cognitive abilities is curvilinear such that low and high levels are both associated with poorer performance than midrange levels.

Data in support of theory: Limited support in general populations, but most recent studies with older men tend not to support this relationship.

4. An earlier age at puberty provides an intelligence advantage

Growth spurts at adolescence are associated with higher mental ability, which means that adolescents who achieve puberty at a younger age will have a cognitive advantage because they will be able to benefit from this advantage over a longer period of time.

Data in support of theory: There is some limited support, but the effect is likely to be quite small.

Do high levels of androgens during fetal life influence the cognitive abilities of the developing organisms? In an attempt to answer this question, researchers examined 17 females and 8 males with CAH (Resnick, Berenbaum, Gottesman, & Bouchard, 1986). The CAH girls scored significantly higher than their unaffected relatives on three different tests of spatial ability (out of 5), thus providing evidence that, for females, prenatal androgen is associated with higher spatial ability. The researchers also found that the CAH girls were more likely to engage in “aggressive play,” which provides more evidence for a

causal link between prenatal hormones and behavior in later life (at least for females exposed to very high levels of prenatal androgen). These conclusions have been supported in several studies. A recent study examined the performance of CAH boys and girls relative to healthy control participants who were similar in age and socioeconomic status (Mueller et al., 2008). The researchers used a modified water maze and measured how long it would take to find a safe platform in a large maze of (simulated) milky water. CAH girls with more severe forms of CAH, which presumably reflects greater androgen exposure in utero, demonstrated performance on this visuospatial task that was comparable to that of the control males and the CAH boys. Other secondary measures of testosterone exposure were associated with better maze performance for the CAH children. A recent meta-analysis of visuospatial ability tests (including mental rotation and other standard measures) found that CAH girls perform better and CAH boys perform worse than healthy children (Puts, McDaniel, Jordan, & Breedlove, 2008). The finding of worse performance for boys who experience very high levels of androgens prenatally may seem strange, especially since it is not found as reliably as the conclusion that CAH girls are superior on visuospatial tasks. It seems that the theory of an optimal level of hormones—too low or too high is not ideal—applies to prenatal development.

Readers who have been following the theories of sex hormone action on cognition may be wondering if CAH girls would show a male-typical 2D:4D ratio or a greater incidence of left-handedness. There are some data supporting the prediction of increased left-handedness (Cohen-Bendahan, van de Beek, & Berenbaum, 2005), but the hypothesized digit ratios are less certain. The same meta-analysis that concluded that CAH girls performed better and CAH boys performed worse than controls on visuospatial tasks also concluded that there was little or no relationship between 2D:4D ratios and spatial abilities (Puts et al., 2008). It is difficult to reconcile this conclusion with the research presented in the section on 2D:4D ratios. At this time, the best conclusion is that the relationships among various markers of high prenatal hormones are unresolved. I invite readers to “stay tuned” for the next edition of this book, when, I expect, we will have a better understanding of these complex issues.

It is also interesting to note that CAH girls show other sorts of masculinized behaviors. For example, CAH girls show a preference for “typical boys’ toys”—trucks, blocks, other building toys over typical girls’ toys,” even though their parents give them more positive feedback when they played with female-typical toys (Pasterski, Geffner, Brain, Hindmarsh, Brook, & Hines, 2005). Recall from [Chapter 3](#) that infants as young as 5 months old prefer (some) sex-typical toys—with both boy and girl infants preferring to look at dolls about equally, and with infant boys looking at trucks and dolls about equally and girls looking at dolls longer than they look at trucks (Alexander, Wilcox, & Woods 2009). Thus, the only real difference in toy preference for 5-month-old infants involved the boys’ preference for trucks when compared with girls’

preferences. Data from CAH girls suggest that these preferences may reflect early hormonal effects, perhaps with the boys' preference for trucks in accord with their greater tendency for "rough and tumble play" and girls' preference for dolls reflecting a general attraction for faces.

Additional evidence that there is a biological component to the preference for sex-typical toys comes from studies of monkeys. Among rhesus monkeys, males have a consistent and strong preference for toys with wheels; whereas female rhesus monkeys are more variable in their toy preferences and will play with both wheeled toys and plush toys (Hassett, Siebert, & Wallen, 2008). It would be difficult to argue that their monkey parents provided them with sex-typed toys or encouraged the males to play more with trucks. A highly publicized study of the behavior of chimpanzees in the wild reported that they showed sex differences in their choice of how they used sticks—with more females carrying sticks "in a manner suggestive of rudimentary doll play" and more males using them to poke holes (Kahlenberg & Wrangham, 2010, p. 1067). The research report also noted that some males behaved more like females in their "stick play." Although it is possible that these differences in how male and female chimpanzee in natural settings in Uganda play with sticks reflect some evolutionary tendency for sex-typical toys, it is a long leap from the data to claim that the females were using the sticks the same way as human infants might play with dolls or that the male infants were using sticks as male human infants might play with toy trucks. Sex-typed toy preferences are a good example of the concept that there is a genetic contribution to the environment—individuals are born with certain personality and activity-level predispositions, which in turn influence the experiences that they select from the environment or create for themselves.

Androgen insensitivity All of the studies with CAH boys and girls examined the effect of high levels of prenatal masculinizing hormones. Another pseudo-experimental approach is to examine the effect of extremely low levels of masculinizing hormones. Will such individuals develop cognitive abilities and personality traits usually associated with being female?

Androgen insensitivity (AIS) is the term used to describe genetic males whose bodies are unable to respond to male hormones. (This disorder is also known as testicular feminization.) During fetal development their testes produce the appropriate male hormones, but for reasons not fully understood, their tissues are insensitive to these hormones and development proceeds as though no male hormones are present (Christiansen & Knussmann, 1987). These genetic males develop female genitals, are generally identified as girls at birth, and are usually raised as girls. Complete insensitivity to androgens is very rare, so most AIS individuals are able to respond at least somewhat to androgen. Ehrhardt and Meyer-Bahlburg (1979) reported "a significant, but modest, tendency toward verbal rather than space-form abilities" among genetic males with androgen insensitivity (p. 422). Even if these subjects were

much better at verbal tasks than spatial ones, we would not know if this pattern of results was due to prenatal hormone effects, postnatal hormone effects, or the fact that the subjects were identified and raised as girls. Thus, these results can be used to support either hormonal or environmental effects on cognition. Most AIS girls (and they almost always are identified as girls at birth and reared as girls, most find out about their insensitivity to androgens at adolescence when they fail to enter normal puberty) are typical girls on cognitive and affective measures, although researchers warn that most studies have involved small samples (Cohen-Bendahan, van de Beek, & Berenbaum, 2005).

Taken together, research on the influence of prenatal/perinatal sex hormones on cognitive abilities suggests that the early hormone environment is important in determining the development of one's cognitive potential, although the data do not yet permit any definitive conclusions. In general, high levels of androgens during prenatal development are associated with higher than average levels of visuospatial ability for girls, but not for boys (who may in fact perform less well on visuospatial tasks). Low levels of androgens (or an inability to respond to androgen) are associated with poorer than average visuospatial ability. But remember, even in those instances in which positive effects have been reported, it is very difficult to tease out the contributions of genetic influences, postnatal hormones, and life experiences. Furthermore, abnormal hormone levels could produce results that are not associated with normal levels of the same hormones.

Do Cognitive Abilities Vary Over the Menstrual Cycle?

Monthly fluctuations in sex hormones affect women's cognitive skills.

—Doreen Kimura (1989, p. 83)

Tests to study sex differences don't relate to anything in real life.

—Beryl Lief Benderly (1989, p. 68)

Given that the major female hormones vary in a cyclical fashion throughout the month in adult women, it would seem that cognitive abilities should also vary in a similar cycle if these hormones mediate cognitive processes. For most healthy adult women, both estrogen and progesterone, the major female hormones, are available only in small quantities during the premenstrual, menstrual, and immediately postmenstrual portion of their cycle. Both hormones increase to a peak quantity at approximately midcycle (estrogen peaks slightly before midcycle and progesterone peaks soon after midcycle) and then decline to premenstrual levels. Monthly variations in progesterone and estrogen are shown in [Figure 4.8](#).

Is there any evidence that women's cognitive or intellectual abilities vary during the menstrual cycle? In response to this question, Tiger (1970) wrote:

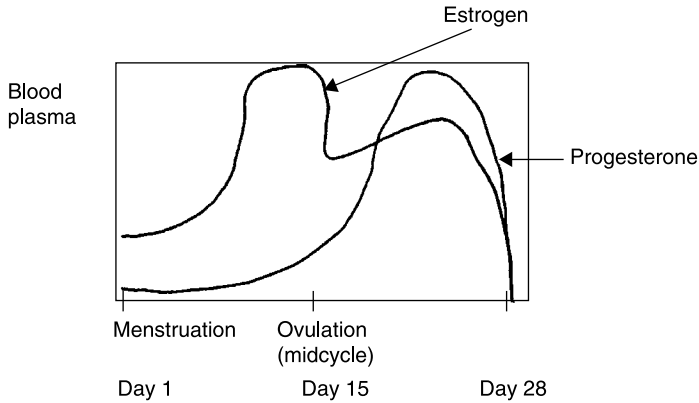


Figure 4.8 Ovarian hormone levels as they vary over the menstrual cycle. Note that both estrogen and progesterone are available in very low levels immediately before and during menstruation and at high levels midcycle.

“An American girl writing her Graduate Record Examinations over a two-day period or a week-long set of finals during the premenstruum begins with a disadvantage which almost certainly condemns her to no higher than a second class grade. A whole career in the educational system can be unfairly jeopardized because of this phenomenon.”

In the first edition of this book that was published in 1986, I wrote: “Research on this question has clearly shown that Tiger is wrong.” More recent research has shown that some cognitive abilities may vary over the menstrual cycle; however, Tiger is still wrong. Before I consider the research that has addressed this controversial question, think about Tiger’s comments. The unstated assumption in Tiger’s statement and those of many others is that women are (or will be shown to be) inferior to men intellectually, at least during some portions of their menstrual cycle. Even if we had solid evidence that monthly hormone fluctuations affect cognition, it would not follow that women are inferior to men either at some portion or during the entire monthly cycle. The finding that women and men differ does not imply that whatever traits are associated with being male are “better” than those associated with being female. Similarly, the mere fact that women’s cognition may vary over the menstrual cycle doesn’t mean that they are more or less intellectually able than men. This assumption is just another example of the “women have less” fallacy. It is the assumption that the study of sex differences will reveal female deficiencies, which has already been shown to be fallacious.

Cognition and cyclical fluctuations in hormones One of the first scientific investigations of whether there are differences in women’s cognitive

functioning over the menstrual cycle was conducted by Golub (1976). Her results with 13 different cognitive tests administered to 50 women aged 30 to 45 showed no significant menstrual cycle effect. Even though some women reported mood changes between the premenstrual and menstrual phases of their cycle, apparently these changes were not large enough to affect their ability to perform cognitive tasks.

However, more recent research suggests that there is evidence to support the notion that women's cognitive abilities fluctuate in a cyclical fashion. First, the idea that cognitive abilities may vary over the menstrual cycle is not viewed as heresy by anyone who has studied sensation and perception. As noted in the previous chapter, there are some differences between men and women in their ability to sense and perceive certain stimuli and in their attentional ability. It is well documented that for women, sensation and perception change at adolescence and also vary over the monthly cycle. Consider, for example, olfaction. A recent review of sex differences in olfactory sensitivity confirms the general finding that women are more sensitive in detecting and remembering odors than men are, but it is probably an oversimplification to conclude that fluctuations of sex hormones over the menstrual cycle cause changes in women's olfactory sensitivity (Doty & Cameron, 2009). It seems that there may be many possible contributors to menstrual-related perception and cognition in addition to fluctuating hormone levels.

The ability to perceive pain is another example of a sensory/perceptual system that shows periodic fluctuation in some, but not all studies. Early experimental research showed that women are more sensitive to painful stimuli during the middle portion of the cycle (when hormone levels are highest) than at menstruation (Goolkasian, 1980;1985). The change in sensitivity to painful stimuli was found only for menstruating women. Women who did not menstruate (e.g., had undergone surgical removal of ovaries) did not show the change in pain sensitivity. Goolkasian (1985) concluded from a carefully executed series of studies, "It is apparent that a woman's ability to discriminate the presence of painful stimuli varies as a function of menstrual phase" (p. 25). More recent research, however, has failed to find differences in pain thresholds for women as a function of their menstrual phase (Klatzkin, Mechlin, & Girdler, 2009). A review of 14 studies of pain perception and menstrual phase failed to find a consistent relationship (Sherman & LeResche, 2006). The various studies differ in many ways that could influence the outcomes, including the type of pain stimulus that was used, the way participants were recruited, and how pain was measured. Thus, based on the most recent reviews, the most likely conclusion is that the relationship does not exist—if it does, the effect is very small, even though there are studies that report menstrual-phase related findings. Recent reviews of the research literature note that sex differences in pain perception are "partly attributable to social conditioning and to psychosocial factors" (Wiesenfeld-Hallin, 2005, p. 137). Women seem to be more willing to report pain and to ask for analgesics, which is consistent with

the female sex role. The literature on sex differences is littered with findings that often do not stand up to repeated replications. It is important to keep in mind a point that was made in [Chapter 2](#). No single study can be used to draw conclusions because there are many ways that single studies can provide anomalous results. Multiple replications of all findings are needed before the results can be accepted.

Although I have mentioned the differences in the concentrations of sex hormones across the menstrual cycle, it might be useful to consider exactly how much the hormones fluctuate. The level of estrogens in adults varies monthly from 3 times as much in women as in men during the portion of the cycle immediately following menstruation to 50 times as much at ovulation. Levels of progestins (e.g., progesterone) vary from equal to that in men following menstruation to 17 times as high closer to midcycle. Conversely, men average about 17 times more androgens than women (Kimmel & Weiner, 1985). Thus, fluctuations of the sex hormones within women across the month and between the sexes are so large that it seems unlikely that they would have little or no effect on men and women.

A well-replicated finding about menstrual cycles is that hormonal fluctuations play a role in mood symptoms, most commonly during the immediate period that precedes the start of menstruation. Thus, any effect that researchers may find that varies across the menstrual cycle could be caused by changes in mood. The premenstrual period is associated with “moderate stress,” which can be tracked in brain imaging studies as well as in participant self-reports (Ossewaarde et al., 2010). Studies of changes in cognition that vary with the menstrual cycle need to ascertain that the results are not due to changes in mood. Anyone who is stressed (or even in mild pain) will tend to underperform relative to their nonstressed self. Mood changes are one possible confound in this area of investigation. Hampson and Kimura (1988; Hampson, 1990a, 1990b) examined whether women’s cognitive abilities would vary as a function of the monthly ebb and flow of estrogen and progesterone. One possibility is that midcycle, when both of these hormones are abundant, women would excel on those tasks that tend to favor women and show a detriment in those tasks that typically favor men. Conversely, at menstruation, when both of these hormones are at low levels, women would show improved performance on those tasks that favor men and decreased performance on those tasks that favor women.

There have been several studies that examined scores on various cognitive tests at different phases of the menstrual cycle and compared them to scores obtained by men. Comparisons have also been made for women who are in different phases of their menstrual cycle. For example, cognitive tests may be taken by women who are menstruating and then again midcycle to determine if the phase of the menstrual cycle affects scores on cognitive tests. In one study with medical school students in Turkey, the researchers used three tests—Finding A’s, which requires respondents to find the letter A as quickly as possible among rows of letters, a mental rotation task, and the Cattell

Nonverbal Test of Intelligence (Halpern & Tan, 2001). These tests were selected because they represent one in which females typically excel, one in which males typically excel, and one in which there are no sex differences. The women showed a slight enhancement on the Finding A's Test and a slight decrement in Cattell scores during the preovulatory phase of their cycle that (probably) coincided with a rise in estrogen.

In another study, researchers compared men and women (in different phases of their menstrual cycles) on performance on a mental rotation test and also used brain imaging (functional magnetic resonance imaging, known as fMRI, which shows areas of the brain that are active during a cognitive task; Schoning et al., 2007). They found that for both women and men, the parietal frontal areas of the brain were active during the task. (These are the side and front areas of the brain.) Activation levels correlated with testosterone for the men, but for the women brain activation levels depended on where they were in their menstrual cycle. During the early follicular stage, women's brain activation correlated with estradiol levels. The authors believe that studies of the relationship of hormone levels and cognitive performance must take menstrual phase into account. These authors believe that the periodic fluctuations seen in women's cognitive performance can explain the variability often found in experimental results. However, in both studies, the hormone-related effects were small and are unlikely to be detected outside the laboratory.

The theory of periodic fluctuations across the menstrual cycle is summarized in [Table 4.4](#).

What do these results relating cognitive performance to menstrual phase mean? These results tell us little about sex differences because only women menstruate, so they cannot be used for between-sex comparisons. Decades of studies on work performance have failed to find any differences in the quality of work done by women in different phases of their menstrual cycle (reviewed in Esgate & Groome, 2004).

Studies with nonhuman animals show cycle-related changes in the structure of neurons, which are the basic cells in the brain that underlie thinking, breathing, and most other life functions. [Figure 4.9](#) shows changes in the

Table 4.4 Do women's cognitive abilities vary across the menstrual cycle?

<i>Portion of cycle</i>	<i>Estrogen</i>	<i>Progesterone</i>	<i>Prediction</i>
Menstruation	Low ↓	Low ↓	Better performances on maps, mazes, and spatial tasks (cognitive tasks on which males typically excel)
Midcycle	High ↑	High ↑	Better performance on speech articulation, manual dexterity, and verbal fluency (tasks on which females typically excel)

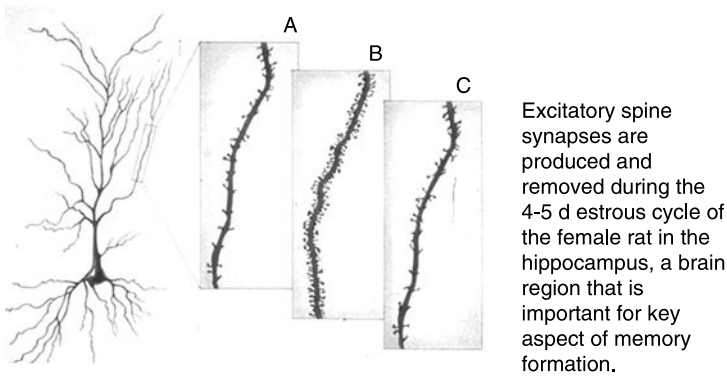


Figure 4.9 These images show changes in neural structures in the brains of female rats as a function of their estrous cycle. From McEwan, B., and Schmeck, *The Hostage Brain*, Rockefeller Press, 1994. Copyright © 1994 The Rockefeller University Press.

“excitatory spine synapses” during different stages of the estrous cycle in female rats. (The fluctuation of hormones in female nonhuman animals is called estrus.) McEwen (undated) found widespread effects of ovarian hormones on the brain that varied across the estrous cycle in rats. He believes that these data from cycling female rat brains have a human counterpart and thus provide a neural basis for menstrual-cycle-related changes in women’s cognitive abilities.

Although studies about monthly variations in the cognitive skills of women were covered extensively by the news services, there has been very little interest shown by the news media in the findings that male hormone and cognitive skill levels also fluctuate. Males show cyclical patterns of hormone concentrations and the correlated rise and fall of specific cognitive abilities, although the cycle is daily and seasonal, not monthly. The spatial skills performance of normal males fluctuates with daily variations in testosterone. Males have higher testosterone levels in early morning than later in the day; visuospatial skills decline for men when their testosterone levels are high and improve when they are low (Moffat & Hampson, 1996). Astute readers may recall that these are correlational data and it is always possible that a third variable is involved—for example, men may be alert in the morning or some other variable is causing these results. Men also show seasonal variations. In North America testosterone levels are higher in autumn than in spring, and spatial skills are correspondingly lower for North American men in autumn and higher in spring (Kimura & Hampson, 1994). In a recent review of sex differences in cognition, Sanders, Sjodin, and de Chastelaine (2002) showed how menstrual cycle phase (across the month) and testosterone variations from morning to night can influence research results.

As you consider this line of research, keep in mind that fluctuations in hormone levels have very little effect on the day-to-day life of normal women or men. Monthly fluctuations within menstruating women and daily or seasonal fluctuations for men tell us nothing about their absolute level of ability. Certainly, there is nothing in this research that could be used to support the notion that women or men are better fit for any type of job.

Hormone Replacement Therapy

Estrogen therapy in open trials has been reported to prospectively benefit cognitive function in nondemented women. There is a reportedly lower prevalence of Alzheimer's disease as a cause of death in elderly women who receive estrogen replacement therapy postmenopausally.

—Bruce McEwen (undated)

Among postmenopausal women aged 65 years or older, estrogen plus progestin did not improve cognitive function when compared with placebo.

—Stephen Rapp et al., for the Women's Health Initiative Memory Study (2003)

If readers have sometimes felt frustrated at the often conflicting findings in the area of hormones and cognitive sex differences, the questions about hormone replacement therapy are sure to induce a migraine. The questions are critically important, not just to individuals who may have hormone deficiencies or who face normal age-related cognitive declines, but to all of society because the percentage and number of older adults is increasing in record numbers in most westernized societies in the world. This is one area of research where I was much more confident about making strong conclusions a decade ago than I am today. There is little to no doubt that "estrogen affects cognitive function" (Luine, Richards, Wu, & Beck, 1998, p. 149), but when considering hormone replacement therapy, it is not always clear if the effect is positive or negative.

Research on the roles of sex hormones in older adults has burgeoned in recent years. Large numbers of postmenopausal women take estrogen replacement therapy (ERT) to prevent osteoporosis and heart disease and to relieve symptoms of menopause including hot flashes and night sweats. For women, the level of circulating estrogen drops sharply during menopause. When the estrogen is replaced, with pills, patches, or other external methods, the prevailing wisdom used to be that healthy older women show a variety of positive effects in cognitive abilities. The number of studies of ERT and cognition is large, so only a sample of the research findings is presented here. Older studies showed that when compared with control groups of women who did not receive ERT, women with replaced estrogen made fewer errors on tests of short-term visual memory and visual perception, and showed stable

performance over time, while the control group declined in their performance (Resnick, Metter, & Zonderman, 1997). ERT also reduced the incidence of Alzheimer's disease by approximately 50% and markedly reduced the symptoms of Alzheimer's disease in women with mild to moderate dementia (Ohkura, Isse, Akazawa, Hamamoto, Yaoi, & Hagino, 1995; Paganini-Hill, Buckwalter, Logan, & Henderson, 1993; Tierney & Luine, 1998). But, these findings have been questioned in more recent research.

Animal studies and human autopsies have shown that estrogen replacement has observable effects on the brain. It spurs neuronal growth and increases the speed of communication among the brain's neurons (Simpkins, Singh, & Bishop, 1994). We now know that there are many estrogen receptors throughout the brain, so it seems logical that estrogen plays a pivotal role in the development and maintenance of a healthy brain. For example, the hippocampus is one of the brain regions that mediates the effect of estrogen on memory (Packard, 1998). It is clear that ovarian hormones have many effects on the brain throughout the life span, including very old age (McEwen, Alves, Bulloch, & Weiland, 1997). So, you may be wondering about the controversy. All of this commonly accepted knowledge by neuroscientists, physicians, and cognitive psychologists about ERT was turned on its head when the results of the Women's Health Initiative (WHI) were announced in 2003. Researchers always knew that there were health risks associated with the replacement of estrogen in older women, including an increase in the risk of breast cancer, so individuals must discuss their personal health risks with medical professionals before deciding about ERT. Many women discontinued ERT or decided not to start ERT based on the negative findings from the WHI.

Because this is a book about cognitive sex differences, health risks that are unrelated to cognition are noted, but are not the main focus of this review. How could the WHI, which was the largest study ever of hormone effects on women's health, arrive at conclusions that were the opposite of those expected by researchers in this field? Does ERT actually harm cognition? Clearly at least some of the many researchers on this mammoth study believe that it does. For example, Rapp et al. (2003) compared results from over 2,000 women who received estrogen in a daily pill with those from over 2,000 women who took a placebo (a "sugar" pill that did not contain estrogen). They reported that for most women, the results from a general cognitive test did not differ between these groups, but a small percentage of women who took the estrogen had "clinically important" cognitive declines. A subset of the participants from the WHI study participated in a "Memory Study," which showed decrements in verbal memory and in mental rotation and decrements in brain volume (Coker et al., 2010). The response from the research community and many women and their physicians was a very loud, "YIKES!"

Official reports from the WHI were startling. Shumaker, Legault, and Coker (2006) and others (Craig, Maki, & Murphy, 2005) reported that "estrogen plus progestin therapy increased the risk for dementia" (p. 2651). How could

laboratory, animal, and neuroimaging evidence suggest that ERT was beneficial to human cognition if it really was detrimental (Low & Anstey, 2006)? Many researchers addressed the diametrically opposed conclusions regarding ERT and cognition. Siegfried (2007) summarized the loud response to the conclusions from the WHI. The biggest problem with the WHI study was the age of the participants, which ranged from 65 to 79 years old. In westernized countries, the mean age for menopause is 51, long before the youngest participants in the WHI study began their estrogen therapy. Like others, Siegfried believes that there may be a critical window for ERT and, if it is taken during that time period, the results are beneficial. Schmidt, a neuroscientist at the U.S. National Institute for Mental Health believes that taking ERT around the time of menopause (51 years of age), will reduce the risk of dementia, but waiting more than a decade longer will have the opposite effect. The reasoning is that young healthy neural cells are protected by estrogen, but if cells are already diseased (perhaps in an early but still undetected state of Alzheimer's disease) then adding estrogen could accelerate the damage. This possibility, which has animal research to support it, could explain why earlier studies showed that estrogen was beneficial for women's brains and the WHI study showed that it was detrimental.

The idea of a critical period during which ERT is beneficial and after which it is detrimental is also supported with studies of women who had their ovaries surgically removed (hysterectomies). These women have a very large risk of increased dementia or cognitive impairments (by as much as 45%); however, if ERT is given up until the age of normal menopause (age 51), then the risk for dementia and other types of cognitive decline did not differ from that of women who had not had the surgery (Hogervorst & Bandelow, 2007). The authors of this study conclude that their findings are consistent with the idea that there is a "window of opportunity" for beneficial cognitive effects from ERT. Numerous other concerns about the WHI study have cast doubt on their findings (e.g., the percentage of women who took the pills consistently was 47%) and have reaffirmed the idea of a window of opportunity (e.g., Luine, 2008). Finally, a study of total lifetime exposure to estrogen has found that a greater amount of exposure to estrogen over an entire lifetime may be associated with better verbal memory (Ryan, Carriere, Scali, Ritchie, & Ancelin, 2009). Women who begin menstruating at a young age, experience menopause at an old age, and have few or no children will have greater lifetime exposure to estrogen than women who do not have these experiences. It seems that when considering the effects of hormones on cognitive function, there are many relevant variables, so it is not surprising that there are so many discrepancies in this area of research.

Men also have estrogen receptors in their brain, with much of the estradiol used by men's brains converted from testosterone. Unfortunately, we know very little about the use of estrogen replacement in older men. Some researchers believe that the conversion of testosterone to estradiol in men gives them the

advantage of estrogen when compared with same-aged women who do not take ERT (Sternbach, 2003). The concern that external estrogen supplied in pill, patch, or other form will feminize their body has made this a difficult area to study. Men also suffer less than women from Alzheimer's disease, both in terms of the percentage who get the disease (even when controlling for the fact that, on average, men die earlier than women) and in the severity of the dementia, although there are many men with Alzheimer's disease (Buckwalter, Sobel, Dunn, & Diz, 1993). At the time of this writing, we do not know if ERT will reduce the incidence or severity of Alzheimer's disease in men, which should not be surprising given that researchers disagree over its effects in women.

Research on testosterone replacement is many years behind research on estrogen replacement, but it is now being conducted at a rapid rate. Low testosterone levels are associated with a wide range of problems including deteriorating memory, fatigue, and reduced sex drive (Sternbach, 2003). When older men with Alzheimer's disease were put on a 24-week regimen of testosterone (in the form of a patch) they reported several benefits, although the improvements on cognitive tests did not achieve statistical significance, possibly because of the small sample size (Lu et al., 2006). The authors of this study report that testosterone replacement improved the quality of life for men with Alzheimer's disease, but had minimal effects on their cognition. It seems unrealistic to expect testosterone to reverse the destructive effects of Alzheimer's disease. It is more likely that testosterone acts like estrogen in that there is a window of opportunity to protect or delay the onset of Alzheimer's disease, but once it occurs, it cannot be reversed.

Sex Hormones, Sexual Orientation, and Cognition

Hormones do not exert their actions simultaneously or directly, but rather they exert their influence in concert with many other biological events in a variety of different systems. There appears to be a running conversation in the CNS among hormones, neurotransmitters, neuromodulators, and probably other, as yet unknown, elements of CNS function.

—F. Robert Brush and Seymour Levine (1989, p. xiii)

Unless you are familiar with the theories in this area, you are probably surprised to learn that some theorists have suggested a link between sex hormones, sexual orientation (being gay, lesbian, bisexual, heterosexual), and cognitive abilities. Research with nonhuman animals (rats, hamsters, ferrets, pigs, zebra finches, and dogs) has shown that prenatal sex hormones contribute to variations in sexual orientation. In Adkins-Regan's (1988) and James' (1989) reviews of the literature relating to the effect of prenatal sex hormones on sexual orientation, they concluded that early castration of males or early

testosterone administration to females can change sexual orientation in nonhuman mammals. Of course, it is always “risky” to assert anything about sexual orientation in nonhuman animals because all we can observe is sexual behavior. Sex orientation in humans is far more complex, involving relational and affectional components.

Recall that Geschwind and Galaburda (1987) hypothesized that high levels of prenatal testosterone alter the innate human bias towards left cerebral hemisphere dominance by slowing its development in early life. As predicted by this theory, left-handedness (a correlate of right hemisphere dominance) is more frequently found in males (who, of course, are exposed to higher levels of prenatal testosterone) than females (Halpern & Coren, 1991; Lalumiere, Blanchard, & Zucker, 2000; Papadatou-Pastou et al., 2008.). It also seems that homosexual men and women also have 50% greater odds of being left-handed (technically called “non-right-handed”) than heterosexual men and women (Lippa, 2003). Prenatal hormone theories suggest that both handedness and sexual orientation are influenced by prenatal androgen levels. It may seem surprising that male homosexuality (being gay) is associated with the more typical male pattern of handedness. In a study of these relationships, Lippa found that being homosexual increased a man’s odds of being left-handed by 82%. Similar data for women showed a 22% increase of being left-handed for lesbians. He also found left-handedness in men was associated with feminine interests and left-handedness in women was associated with more masculine interests than in heterosexual controls. These findings were replicated in the large BBC internet study of sex and cognition, with left-handedness associated with homosexuality in both men and women (Blanchard & Lippa, 2007). Lippa reviewed many theories about the relationship between prenatal hormones, handedness, and sexual orientation, but failed to find a model that would explain these diverse findings. Simple theories such as men with low levels of androgens are more likely to be attracted to male sex partners and perform less well on male-typical cognitive tasks cannot explain the increase in left-handedness for gay men, which is a marker for increased prenatal androgen.

Results from the large BBC internet study of sex and cognition found that heterosexuals of both sexes performed better than homosexuals or bisexuals in gender-typical tests of mental rotation, judgments of line orientation, category fluency, and memory for location (Maylor, Reimers, Choi, Collaer, Peters, & Silverman, 2007). In other words, the researchers replicated previous findings that visuospatial abilities are demasculinized (or feminized) in gay men (e.g., Rahman, Abrahams, & Jussab, 2005; Rahman & Wilson, 2003) and these same skills are masculinized (or defeminized) in homosexual and bisexual women (Rahman & Wilson, 2003; van Anders & Hampson, 2005).

It seems likely that sexual orientation is influenced by a host of factors that may include the effect of prenatal and perinatal hormones on a developing nervous system. Thus far, researchers have not found any social or experiential variables that could predict sexual orientation. Of course, much more research

is needed on this question before we can make any meaningful conclusions. If prenatal hormones are an important factor, then sexual orientation is just another one of the myriad ways in which humans differ. This is all part of natural human variation and does not support any bias that one sexual orientation is “better” or “worse” than another.

It is presumed that both genes and hormones operate via their influence on the brain—that marvelous organ that is responsible for our every thought and action. The question of sex differences in the structure and function of the brain is discussed in the next chapter. General statements about the limitations of biological theories and the way biology interacts with psychosocial variables are also made in the next chapter. So, stay tuned for Biological Hypotheses Part II: The Brain, playing soon in a textbook near you.

CHAPTER SUMMARY

Although most people find the simple question about what makes people female and male to be funny, in fact there are numerous biological and psychological indices of sex, and they are not always consistent. Biology always operates in an environmental context, and it is the influence of biology within an environment that permits or prohibits the development and expression of cognition. Females and males are biological beings, so it should not be surprising to find biological data that are predictive of cognitive abilities.

Research in behavioral genetics has been progressing at a rapid rate in recent years. New conceptualizations now include the idea that individuals influence their environment in ways that make separation of heredity and environment impossible. There is also a new emphasis on the prenatal environment and perinatal hormones as important contributors to developing organisms. Genetic theories have been proposed to explain cognitive sex differences. It seems that females and males are equally affected by heredity and that both general intelligence and separate cognitive abilities are, in part, inherited. Two genetic theories have been proposed as explanation for cognitive sex differences. The “sex-linked recessive gene theory” posits that spatial ability is determined by a recessive gene that is encoded on the X chromosome. Predictions from this theory (such as the proportion of women and men that would be expected to show good spatial ability) have not been supported. The second theory was proposed to explain the usual finding that males are more variable on many cognitive tests. There is good evidence that some types of mental retardation are X-linked so they are more prevalent in males, but no high intelligence genes are known to influence the development of high levels of intelligence, so this theory is partially correct.

Prenatal and early postnatal sex hormones exert organizational effects on the developing brain, but as expected the effect of sex hormones on the brain is complex. Four different theories of hormone effects on cognitive sex

differences were discussed. It is likely that higher levels of androgens prenatally are associated with right hemisphere brain dominance, which can be seen in the increase in left-handedness for males and male superiority on cognitive tasks associated with activation of the right hemisphere, with the opposite results for females. The ratio of the length of the index to the ring fingers was also proposed as a marker for hormone effects in prenatal life because the same family of genes that affect digit growth affect the growth of the genitals. A very large research literature seems to support this theory. But, the effect of hormones on cognition is not linear; it is more likely that an “optimal level”—neither too much nor too little—is important for cognition. Finally, the idea that an earlier age for puberty would be associated with better cognition has minimal support.

There is some evidence that cognitive abilities vary over the menstrual cycle for cycling women and over the day and seasons for men, but the effects are very small and not meaningful in most everyday tasks. The massive Women’s Health Initiative (WHI) study published the surprising results that estrogen replacement therapy had detrimental cognitive effects in older women, including increased dementia and brain shrinkage. Criticisms of these results have suggested that the women in the WHI were well beyond the age of menopause and that different results might have been achieved if estrogen had been administered during a “window of opportunity” that is closer in time to menopause. In aging men, there is some evidence that testosterone replacement can be beneficial for cognition, but much more research is needed before strong conclusions can be made.

It is clear that hormones that are important in reproduction are “also important for normal healthy sex-specific brain development and function” (McEwen quoted in Becker, 2005). New findings about the ways hormones influence brain functioning are revitalizing the entire field of sex differences in neuroscience.

Finally, the growing research literature on cognitive differences as a function of sexual orientation (lesbian, gay, straight) was reviewed. In general gay men and lesbian women perform less well on sex-typical tasks (e.g., better verbal memory for women and better mental rotation for men) than heterosexuals and these differences may be due, in part, to different prenatal hormone environments.

Biological Hypotheses Part II: Brains, Evolutionary Pressures, and Brain– Behavior Relationships

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Chapter Summary

Men's and women's brains are to a significant extent wired differently from the start.

—Doreen Kimura (1996, p. 259)

A BRIEF INTRODUCTION TO THE BRAIN

Every thought you have ever had, every movement you have ever made, every emotion you have ever felt were brought to you by that amazing mass that sits within your skull. If you could examine your own brain, you would, no doubt, be surprised to find that it looks like a giant mushy walnut with the consistency of a soft-boiled egg, weighing approximately 3 pounds (1.36 kilograms). The brain and the spinal cord attached below it make up the central nervous system. Not surprisingly, researchers have considered the possibility that sex differences in cognitive abilities may, in part, reflect sex differences in the underlying neural structure or organization of the brain. All intellectual activity results from patterns of neural activation by large groups of neurons. So that you can follow the logic of the research that has investigated sex-related brain differences, I will begin with a brief introduction to the brain. Knowledge of basic brain structures is needed to understand if, how, and by how much males and females differ in their brains. It would be meaningless to know that some researchers found size differences in some part of the brain without knowing the role of that part of the brain in cognition.

Look carefully at the picture of a human brain in [Figure 5.1](#). You are looking at the brain “head on,” it appears bilaterally symmetrical (each half looks the same). Each half of the brain is called a hemisphere. The two hemispheres are connected by a thick band of neural fibers called the corpus callosum. In addition to “brain cells,” called neurons, there are spaces in the brain that are filled



Figure 5.1 Our beautiful brain.

with cerebrospinal fluid—a fluid that serves two purposes. It helps to cushion the brain against injury and carries hormones and nutrients (glucose and oxygen) to different parts of the brain. The brain is truly awesome in light of all that it does.

Cerebral Cortex

When you look at the outside of the brain, what you are looking at is the cerebral cortex. It is the outer portion of the brain. In humans, the cortex is the largest and most complex part of the brain. Its highly convoluted (wrinkled) appearance is the distinguishing feature between human brains and those of other animals. The cortex is what makes us human—it is the part of the brain that performs complex reasoning. Researchers believe that the cortex is wrinkled because it allows more surface space to fit inside the relatively small skulls that house our brains. In humans the cortex is the size of a large sheet of newspaper that has been wrinkled to fit into a small space.

Different parts of the cortex are specialized for different functions, and different aspects of the same cognitive function can take place in different locations in the brain. The cortex is divided into four parts called “lobes.” The frontal lobe is the area in the front part of your head. It is the largest part of the human brain, and its complexity is what sets human brains apart from those of other animals. The temporal lobes are on both sides of the head above the temples. The temporal lobes house the auditory cortex, which is the primary site for processing auditory information. They also house the hippocampus and amygdala, important for memory and emotion, which are discussed in more detail below. The occipital lobe is in the back of your head. It is devoted almost exclusively to vision. The parietal lobe is along the top. It integrates much of the touch, vision, and other sensory information we receive. The four lobes of the brain are shown in [Figure 5.2](#).

Cerebral Hemispheres

A distinguishing feature of all human brains is that they have two hemispheres that appear highly similar. A closer investigation shows that in fact there are important differences in the hemispheres. For example, one part of the brain that is known as Wernicke’s area is primarily responsible for comprehension of speech, and a different area known as Broca’s area is primarily responsible for the production of speech. For most people, both of these verbal-related areas are found in the left half of the brain. Because of this organization, when a right-handed person has a stroke (a burst blood vessel in the brain or a blockage that prevents the flow of blood), they can usually retain their ability to speak, provided that the stroke occurred on the right half of the brain. This is just some of the evidence the neuroscientists have that the hemispheres serve different functions.

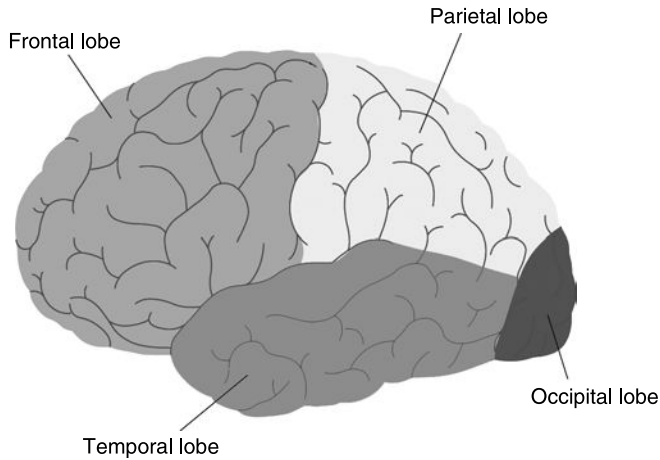


Figure 5.2 The four lobes of the human brain.

The organization of most functions, especially motor functions, is contralateral. This means that the right hemisphere controls the left half of the body, and the left hemisphere controls the right half of the body. Although the brain appears symmetric, extensive research has shown that each side of the brain is primarily responsible for somewhat different functions. The left half of the cortex receives sensory information about the right half of the world and it controls the motor responses on the right side of the body. Sensory information and motor control for the left half of the world are under the control of the right hemisphere. Visual information is transmitted according to the right and left half of the visual field, so unlike other sensory information, everything to our right is initially processed in the right hemisphere, with the left half of the visual field initially processed in the left hemisphere. Information is transferred between the hemispheres via a thick band of connecting neurons. Thus, brain mechanisms for most sensory input and motor output are under contralateral (or opposite side) control.

Brains are lateralized, which means that each of us has one hemisphere that is dominant for many tasks. Handedness is one major marker of brain organization. If you write with your right hand your left hemisphere is dominant for motor functions, and if you are left-handed or a mixed-hand user (someone who may write with one hand and throw a ball with the other hand, for example) it is more likely that you will be right hemisphere dominant. As you read in the previous chapter, there are more males (12.8%) than females (10%) who are left-handed. The exact percentage varies depending on how handedness is measured—some studies just use preferred writing-hand; others also include the hand you use to draw, brush your teeth, and hold a deck of cards, along with other tasks that are mostly accomplished with one hand. Estimates also

vary depending on whether respondents are allowed to select “mixed-hand use” as an alternative to right or left (Lalumiére, Blanchard, & Zucker, 2000). These values may also vary slightly across race/ethnicity and region of the world.

You may have read or heard some “pop” psychology that makes a distinction between people who are “right-brained” and “left-brained.” As you probably have guessed by now, the picture of brain functioning that is emerging is more complicated than a simple division of functions by right or left hemisphere. A focal topic in sex differences research in brain organization concerns the possibility that female and male brains differ in the way the two hemispheres are specialized for different tasks. The brain is divided into regions that are relatively more important for certain tasks and relatively less important for other tasks. For example, some structures in the brain are more important in understanding language or processing emotions than other regions are. In general, and especially for most right-handed people, the language areas of the brain are found in the left hemisphere, which tends to be more involved in symbolic and analytic thought processes. For most people, the right hemisphere is involved more in perceptual and spatial processing. Research on the specialization of the two hemispheres suggests that the difference between verbal (sequential) processing and spatial (analog) processing is a “fundamental dichotomy in human cognition” (Lohman, 1988, p. 182), with different brain regions involved in the sequential analytic processing best suited for verbal tasks and the simultaneous, holistic processing best suited for spatial information tasks. In other words, tasks like reading or following instructions must be completed in a fixed order or sequence, whereas tasks like processing information from a diagram are simultaneous because we can process information from several parts of the diagram at the same time. Our brains seem to be organized to support these two different ways of processing information.

What and Where Pathways

One distinction that is consistent with the idea that our brains evolved in response to adaptive pressures is the separation of visual information about what an object is from where an object is located (Braddick, 1993; Brown & Kosslyn, 1995). Recall from [Chapter 3](#) that females are generally better on memory tasks, including memory for an object they saw (e.g., a pencil) and where it is located (e.g., on the desk to the right of the computer keyboard) whereas males tend to excel on other visuospatial tasks. What and where information is handled by two different kinds of neural encoding. As an example of how research into this distinction is conducted, consider two different cognitive tasks—one that requires memory for what an object is, regardless of where the object is located, and another that requires memory for the location of an object, regardless of the identity of the object. Using this research paradigm, Mecklinger and Müller (1996) recorded EEGs from different positions on the

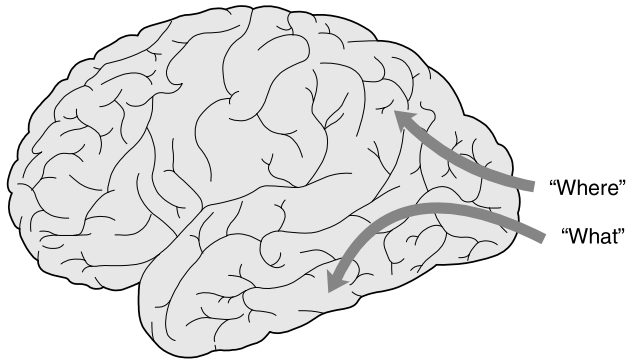


Figure 5.3 The “What–Where” pathways in the brain.

scalp and found that “object and spatial information . . . are subserved by functionally and anatomically different subsystems” (p. 453).

Visual information enters the brain through the eyes. It then connects with neurons in relay stations on the way to the occipital cortex, which is the back area of the brain. The visual information then separates. Neural pathways that allow us to know where something is in space project into the parietal areas of the brain and information about what we saw is projected into the temporal lobe. These two different pathways for visual information are graphically shown in [Figure 5.3](#).

Evolutionary theory would predict sex differences in the functioning and neuroanatomy of the “what” and “where” brain systems because of the differential importance of what and where information for gatherers and hunters in early societies. As far as I know, this prediction has not yet been tested, although I know of several studies of this hypothesis that are in progress. Advances in brain recording and imaging are moving rapidly, and we are still new at using them to reveal the mysteries of the brain. The application of these techniques to questions of sex differences usually lags behind their primary use as a basic technique to study brain–behavior relationships. Perhaps by the time you are reading this text, experiments comparing males and females with regard to brain activity in what–where tasks will have been published. Thoughtful readers are invited to speculate on what the results of these yet to-be-conducted studies might show and how findings are likely to be interpreted.

The New Pink and Blue: Gray and White Matter

Simply put, your brain is what you do with it.

—Lise Eliot (2009, p. 6)

Neuroscientists use the term “gray matter” when they refer to clusters of cell bodies and their synaptic connections anywhere in the central nervous system.

The cortex, for example, has a gray appearance because large numbers of cells are located there. “White matter” refers to axon tracts, the bundles of spidery extensions that project from the cell bodies and send their output to other neurons. Often, the axons are covered with a fatty sheath (myelin) that gives them a whitish appearance that looks like branches. Gray matter represents the information processing centers in the brain, and white matter represents the networking of—or connections among—these processing centers. The cortex covers other brain structures that lie deeper within the hemispheres. It is the interconnections among cortical and subcortical neurons that underlie complex cognitive abilities. Neurons do not touch each other; they are separated by microscopic gaps called synapses. Neurons connect or communicate with neighboring neurons via the release of neurotransmitters, which are chemicals released into the synapses between the axon terminal endings of the neuron sending the message and the dendrite (receiving end) of the neuron receiving the message. The message is often simple: fire or stop firing, but each neuron has multiple endings and synapses so the communication patterns are incredibly complex. (There are several excellent introductory texts that explain these processes. See, for example, Gazzaniga, Heatherton, & Halpern, 2009.)

In general, women have relatively more gray matter (than white matter) and men have relatively more white matter (than gray matter) in their brains (reviewed in Lenroot & Giedd, 2010). But, when studies control for overall brain size, the differences in the ratios of gray matter to white matter are minimal, which means that males and females with equal brain sizes (usually measured as brain volume) will have nearly equal gray:white matter ratios (Leonard et al., 2008). Given that the ratios become very small when controlling for overall brain size, it does not seem likely that differences in the ratio of whole brain gray and white matter are important for understanding differences in the functioning of males’ and females’ brains. However, it may be that there are sex differences in gray/white matter ratios in specific brain areas.

In one classic study, researchers examined the relationship between gray and white matter and scores on a standardized intelligence test. The men and women in this study were matched on IQ scores, in order to determine whether, given equal intelligence, the amount of gray and white matter correlates with IQ scores in different ways for women and men (Haier, Jung, Yeo, Head, & Alkire, 2005). The researchers found differences in the patterns of correlations with general intelligence scores. These are shown in [Figure 5.4](#). The men had approximately 6.5 times the amount of gray matter related to general intelligence than women, and women had nearly 10 times the amount of white matter related to intelligence than men. The researchers concluded that “Men and women apparently achieve similar IQ results with different brain regions, suggesting that there is no singular underlying neuroanatomical structure to general intelligence and that different types of brain designs may manifest equivalent intellectual performance” (p. 320).

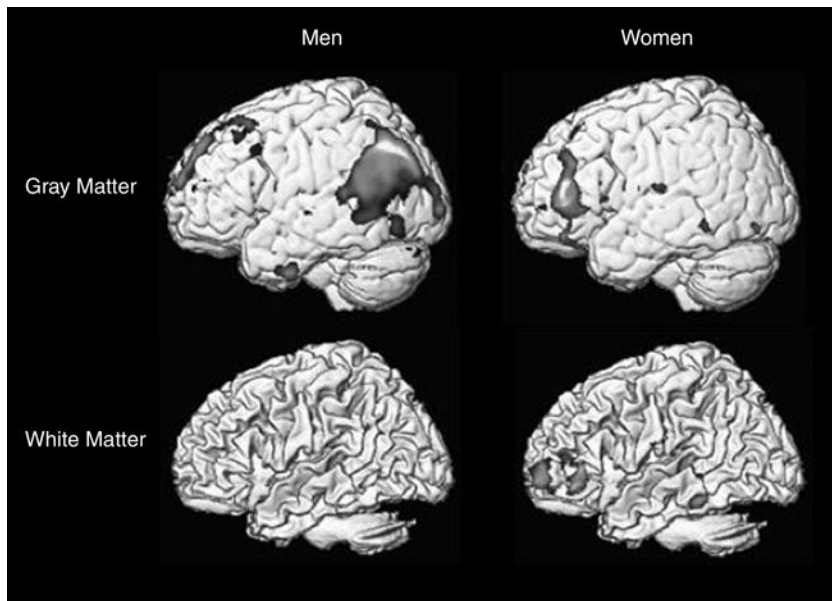


Figure 5.4 These (average) brain images show the areas that are correlated with intelligence, separated for males and females and gray and white matter. Notice that different proportions of gray and white matter correlate with intelligence for women and men. Image shows data from Haier, Jung, Yeo, Head, and Alkire (2005). Reproduced with permission from the author.

Not surprisingly, the search for the brain basis for intelligence turns out to be a very difficult task because different abilities, such as visuospatial abilities or mathematical ability, rely on different regions of the brain, and there may not be a single brain basis for any of the abilities that differ (on average) by sex. Our most current understanding of the complex question about the relationship between brain structures and intelligence points to a network of structures that integrate parietal and frontal lobe functioning. This theory is called P-FIT (parietal and frontal integration theory) and there is a rapidly growing body of research on this theory (e.g., Deary, Penke, & Johnson, 2010; Jung & Haier, 2007). The underlying idea is that humans process most of their information through auditory and visual pathways in the posterior brain that then “feed forward” (Jung & Haier, 2007, p. 138) for abstraction and elaboration. Based on measures of white and gray matter in these areas of the brain, researchers have suggested that, on average, women’s performance on measures of intelligence may be more closely related to language centers in the brain than is men’s (Haier et al., 2005). Moreover, different areas of the frontal and parietal lobes are correlated with IQ for men and women. It is important to remember that these findings were based

on research in which the women and men were matched on IQ, so the conclusion is not that there is a smarter sex or a better mix of gray or white brain matter, but that women and men may achieve equal intelligence using different regions of their brain. Other studies have confirmed the finding that multiple areas of the brain are involved in intelligence (Colom et al., 2009).

Another approach to understanding how gray and white matter contribute to intelligence used a battery of tests to create two separate measures of intelligence (Johnson, Jung, Colom, & Haier, 2008). One of these measures combined verbal ability with mental rotation ability (the visuospatial ability that shows the largest difference between females and males, as explained in [Chapter 3](#)) into a single variable. Individuals who tend to be high on this measure show greater mental rotation ability and those who tend to be low on this measure show greater verbal ability. A second measure concerned attention—whether attention is diffuse (individuals pay attention to many different stimuli at once) or focused. Johnson and her colleagues have proposed that these two dimensions are a better way of conceptualizing sex differences in intelligence (Johnson & Bouchard, 2007b). As expected, researchers found correlations with gray and white matter in areas of the brain that are related to language processing and mental rotation and in areas related to attention. They are not arguing that gray or white matter is better or that it is more important to be high in mental rotation or verbal ability. As brain researchers, they are looking for basic brain structures that correlate in different ways depending on what is being measured. The authors use these data to argue that sex differences in intelligence reflect differences in brain structure.

There have been fewer studies of the contribution of white matter to intelligence than gray matter, but it is clear that myelinated axons are critical in the efficient transmission of information (C. Y. Tang et al., 2010). (Recall that the white appearance comes from the myelin coating on some axons—the long part of the neuron that communicates with other neurons; Jung & Haier, 2007.) Research that looks for brain structures that correlate with intelligence is based on several assumptions. First, correlating IQ measures with total brain size is too simplistic because IQ measures are made up from different patterns of cognitive abilities, and not all areas of the brain are equally important for intelligence. Therefore, imaging studies use both separate measures of cognitive abilities (e.g., mental rotation–verbal) and general measures like IQ to look for correlations with white and gray matter in specific areas of the brain. Second, researchers who investigate the relationships between brain structures and intelligence argue that there are brain correlates of intelligence tests and these correlations differ between males and females. Since test scores are related to features of the brain, these studies do not support claims that intelligence test scores are meaningless numbers unrelated to anything important. The data presented here (and many more studies not included in this review) show that there is a brain basis for differences in IQ scores, although the importance of sex differences in brain structures is far from being fully understood.

In thinking about possible sex differences in the brain, it is important to keep two facts in mind. First, the brain as a whole integrates information, so when researchers compare white and gray matter, it is easy to lose sight of the fact that both are essential for intelligence. Second, it is a fundamental fact that brains are plastic or malleable; they change in response to their environment, so even if we were to conclude that some brain area is, on average, larger for one of the sexes, the size differential could have been caused, at least in part, by sex-differentiated life experiences. Arguments that focus on psychosocial factors are presented in [Chapters 6](#) and [7](#).

HORMONAL INFLUENCES ON THE BRAIN: A DEVELOPMENTAL PERSPECTIVE

Sex differences in the nervous system come in many forms.

—Stuart Tobet et al. (2009, p. 387)

As explained in [Chapter 4](#), brain development begins during the same prenatal period in which the genitals are forming, and both the newly forming brain and sexual differentiation of the genitals depend on the type and quantity of sex hormones that are available. Sex differences in the brain develop through genetic and hormonal action (Tobet et al., 2009). There are very large differences in prenatal hormones for female and male fetuses. For humans from 34 to 41 weeks gestational age—an interval in time when the brain is undergoing major developmental changes—testosterone levels are 10 times higher in males than in females (Swaab, Zhou, Fodor, & Hofman, 1997). In addition to those periods in the life span when hormonal effects on the brain are especially critical, there is a life-long relationship between brain development and functioning and concentrations of sex hormones. Thus, brain development is best conceptualized as a developmental process starting at the beginning periods of prenatal life and continuing into very old age. Brain development varies for different neural regions at different times in the life span, affecting different behaviors (Collaer & Hines, 1995).

Prenatal Period, Infancy, and Childhood

With all due consideration for the contribution of social-cultural factors, it seems probable that these sex differences [in cognition] also reflect underlying differences in brain organization, presumably induced by different prenatal hormonal environments.

—Jan W. Van Strien and Anke Bouma (1995, p. 137)

As explained in the previous chapter, many brain regions respond to estradiol (a form of estrogen) that is converted from testosterone, which then

masculinizes the brains of normal males. It seems ironic that estradiol, a variant of what is usually considered a female hormone, is the predominant hormone in the development of male brains. Although most of the research in this area has focused on the way testosterone affects brain development, we now know that ovarian hormones are also important in the sexual differentiation of the female brain (Fitch & Denenberg, 1998; Kudwa, Harada, Honda, & Rissman, 2009).

According to earlier accounts of brain development, the female brain was the “default template” or prototype that developed in the absence of testicular hormones—just add (usable) testosterone to make a male brain, omit it during the prenatal period and you would get a female brain. Recent research has shown that this theory of brain development is wrong. There is abundant evidence that ovarian and testicular hormones are *both* critical determinants of whether a brain will develop in a female or male direction. Research has also shown that brain portions that underlie some of the sensory systems also respond to early life hormones and thus there could be underlying sex differences in some of the sensory systems (Horvath & Wikler, 1999). The presence, absence, and proportional mix of these hormones affect the neuroanatomy of the brain, sexual behavior of the organism, and the extent to which sex-typical cognitive abilities develop in later life. Fitch and Denenberg (1998) summarized this important finding in a cleverly worded pun, “Default is not in the female, but in the theory” (p. 341).

The first two years of life are also critically important in brain development. Hormone levels are particularly high in the first six months of life for both girls and boys, when they experience a postnatal surge that is sometimes called a “minipuberty,” and then hormones drop to low levels and remain stable at these low levels until age 10 or 11 (Eliot, 2009). The rate of brain development parallels the ebb and flow of sex hormones throughout childhood. Beginning soon after birth, the brain’s neurons form new synapses (microscopic spaces that connect neighboring neurons) at a high rate of speed. The brains of most 2-year-olds contain twice as many synapses as that of the normal adult (Nash, 1997). The number of synapses remains relatively stable between age 2 and age 10 or 11, when the connections are selectively pared or pruned. Thus, it seems that the intellectual gains associated with puberty are correlated with (selective) neuronal death, a process that presumably eliminates redundant connections and allows for increased efficiency in those that remain.

At around the time of birth, the average human brain weighs approximately 350 grams (12.35 ounces), by age 2 it has reached about 75% of its adult weight, and by age 5 the brain is at approximately 95% of its adult weight (Giedd, 1999; Martin, 1998). The next time you have an opportunity to spend some time with toddlers, notice how large their heads are relative to their body size, reflecting the early development of the brain. Functional asymmetry, that is the specialization of each hemisphere for some types of cognitive processing, begins prior to birth and may be fairly complete by age 5 or 6 (Martin, 1998).

Different parts of the brain mature at different rates proceeding from left to right and anterior to posterior with the frontal lobes maturing later than most other areas of the brain.

Puberty and Adulthood

Although a better understanding of how sex differences develop during childhood and adolescence may eventually help to guide interventions such as treatment and education, it should be remembered that all the findings . . . represent group averages with substantial overlap between groups. Causality has not yet been established between any normal variation of brain development and functional ability.

—Roshel K. Lenroot and Jay N. Giedd (2010)

By the time individuals reach puberty, their brains are functioning at a sophisticated level, owing to the complex interplay of experience and physical maturation. The process of myelination, which is the development of the fatty covering of the axons, continues into adulthood, perhaps up to age 60 (and possibly beyond). It has generally been believed that younger individuals recover from brain damage better than older ones because younger brains are more “plastic,” or able to transfer cognitive functions from one area of the brain to another. Studies reviewed by Martin (1998) show that, as a general principle, this adage is true.

The most conspicuous sex difference in the human brain is found at puberty. One area of particular interest is a structure in the hypothalamus (more specifically the anterior hypothalamus). Recall from [Chapter 4](#) that the hypothalamus is an important brain structure that is involved in many human functions, especially because it communicates with the pituitary gland, which then secretes gonadotropins. This brain structure has been described as “sexually dimorphic,” which means that it has a somewhat different structure in females and males. One part of the hypothalamus (the nucleus of the preoptic area [POA]), is so much larger in males than in females that the size difference is visible with the naked eye. (Readers with a good background in this area will want to distinguish between the SDN-POA, which is used when referring to rats, and the interstitial nucleus of the anterior hypothalamus or INAH-3-POA, which is used when referring to humans.) These findings were reported long ago with rats, but only within the past two to three decades with humans (Gorski, Gordon, Shryne, & Southam, 1978). “Sexually dimorphic nucleus of the preoptic area” may seem like a long name for a small brain part, but in this case the question of size is important. LeVay (1991, 2007) reported that this part of the POA is smaller in gay men than in heterosexual men, and this renewed debate about whether sexual orientation is a conscious choice or a biologically based disposition. I return to this question later in this chapter. This small brain part with the long name may change how we think about

human nature. More recent work has focused on this tiny region of the brain as a possible brain locus of whether we think of ourselves as male or female. Researchers found that the size of this tiny organ is smaller in heterosexual women than heterosexual men (men's INAH is about 2.5 times as large as it is for women), and that for male-to-female transsexuals the size of the INAH is similar to that of heterosexual women (Garcia-Falgueras & Swaab, 2008).

The Aging Brain

The brains of men aged faster or earlier than those of women.

—Patricia E. Cowell, Bruce Turetsky, Ruben C. Gur, Robert I. Grossman,
Derri L. Shtasel, and Raquel Gur (1994, p. 4748)

By age 70, brain volume is reduced by approximately 6%, with the greatest loss seen in the frontal cortex (Cowell et al., 1994; West, 1996). New methods of imaging the brains of healthy humans, coupled with huge increases in the number of elderly, have created a flurry of research on the aging brain. The decline in some intellectual abilities with increasing age for healthy, older adults and the increased incidence of many types of dementia as a function of increasing age have naturally led to the question of whether the neural changes in the aging brain can be linked to the age-related changes in cognition.

Many studies have found sex differences in the way the brain ages, with men's brains aging faster than women's brains. The brain contains receptors for androgens and estrogens, which are distributed in varying concentrations in different parts of the brain. The uneven distribution of these receptors provides a theoretical basis for finding that different regions of the brain decline at different rates for women and men. A related hypothesis is that female sex hormones may protect female brains from age-related atrophy (Gur et al., 1991). Research has shown that estrogen influences the morphology (structure) of the glial cells in the brain, suggesting ways in which male and female brains differ that depend on the availability of hormones (Mong, Kurzweil, Davis, Rocca, & McCarthy, 1996). Glial cells are not neurons; they protect and nurture neurons and thus are critical for normal brain functioning. Research also shows sex differences in aging with respect to the two halves of the brain. Gur et al. (1991) found that the left hemisphere showed the greatest effects of atrophy in aging men, with more symmetrical effects found in the aging brains of women. These authors concluded that women are less vulnerable to age-related changes in mental abilities; whereas men are particularly susceptible to aging effects on left hemisphere functions.

But, like every topic in this book, there are also studies that fail to support the conclusions from previous research. In a very large study of aging brains, researchers found that although brains do atrophy in old age, with detectable differences in only one year, sex differences in the rate of atrophy were "minute" (Fjell, Walhovd, & Fennema-Notestine, 2009; Fjell, Westlye et al.,

2009). It is difficult to know how to reconcile different findings. It is clear that the brain has been slow in giving up its secrets. Recall from [Chapter 4](#) that when estrogens were administered to women in their 60s and older, researchers from the Women's Health Initiative warned that the estrogen was associated with brain loss, but other studies suggested, but did not prove, that there might be an opposite outcome if the estrogens were administered to women in their early 50s, around the time of menopause. With so many moderating variables it is not surprising that research results are often inconsistent, especially in small samples that may not be representative of all men and women. All science proceeds with early findings modified by more recent research. This sort of progression in our understanding of how the brain works in ways that are similar and different for females and males is like all scientific knowledge. With time, we will discover the way moderating factors influence inconsistent findings as we unlock the secrets of the brain.

ENVIRONMENTAL INFLUENCES ON THE BRAIN

Experience is the chief architect of the brain.

—Bruce Perry, MD (Baylor Medical College, cited in Nash, 1997, p. 55)

In understanding sex-related differences and similarities in the human brain, it is important to keep in mind the fact that there are many variables that affect brain structures. Neural structures can change in response to some environmental events, but the details are far from clear. In fact, it is often difficult or impossible to classify a variable as primarily biological or primarily environmental. Structural and functional differences in the anatomy of the brain result from different environmental experiences and cause individuals to select different experiences from the environment. In an influential study with rats, Greenough, Black, and Wallace (1987) showed that intellectually enriching environments caused neural growth in the brain and created new connections among neurons. Numerous studies (presented later in this chapter) show changes in cortical representations that occurred after specific experiences. What people learn influences brain structures such as dendritic branching and cell size; brain architecture, in turn, predisposes individuals to seek additional experiences. Hormone secretions, already identified as important in brain development, are also affected by a host of environmental stimuli such as prolonged stress, drug use, and starvation.

Consider these examples of environmental influences on the brain, excerpted from Mascie-Taylor (1993): home environment, obstetric complications, maternal smoking, occupational level, family and school moves, geographical region, myopia, nutrition, and lead exposure. The list of environmental variables that affect brain development is virtually endless, and the number of

possible combinations of environmental effects is beyond our comprehension. It is easier to see how extreme changes cause effects on the brain, but the normal day-to-day changes are harder to find in the brain. Consider the long-term consequences of being born to a mother who smokes, a behavior that is usually considered to be relatively benign. Babies born to mothers who smoke have, on average, lower birth weights and smaller brains. Children born to mothers who smoke are more likely to be left-handed, possibly reflecting hypoxia (reduced oxygen around the time of birth; Bakan, 1990). Low birth weight children have specific visual-motor and spatial skills problems (Brooks-Gunn, Liaw, & Klebanov, 1992), so although not everyone who is born to a mother who smokes will have these problems, they tend to be associated.

Environmental influences early in life, like being born to a mother who smokes, are not the only environmental factors that have demonstrable effects on the brain. Unfamiliar tasks may utilize different neural substrates than well-learned ones, even in adults. Voyer (1995) found that the left hemisphere is more active during the early learning stages of a new task, but the right hemisphere takes over as the task became well learned, with sex differences in the way the hemispheres shifted in representation as a function of practice. In musicians who began their training at a young age the corpus callosum is larger than in matched controls (Schlaug, Jancke, Huang, Staiger, & Steinmetz, 1995). Numerous functional changes in the brain have been found with musical training (Herdener et al. 2010). So, if you are sorry that you stopped or never started piano or violin or some other musical instrument, there is strong evidence that you should start (or start again) for positive life-long brain effects because the brain continues to respond to environmental events, such as learning a musical instrument, into old age. The authors of these studies believe that the corpus callosum is larger in musicians because of their early musical training, suggesting that when interventions occur early in life, brain changes are larger and longer-lasting. This finding with musicians who began training when they were young was especially true of those who practice extensively with the use of both hands in producing music; different areas of the brain respond to music for those who have trained compared to those who have not trained with an instrument.

There are many studies of the effect of environmental influences on brain structures. For example, experimental data with rodents show clearly that the amount they are handled affects brain development, with measurable differences for several brain structures (e.g., Juraska, 1991). In a review article of the way the brain responds to environmental enrichment, Diamond (1988) explained how experimental studies with rats have profound implications for humans. When rats are given “toys” to play with and other enriching experiences, their cortex becomes thicker and several other areas of the brain show neuronal changes. Relative to control rats, these lucky rats ran mazes better, utilized less brain glucose (probably because they have more “efficient” brains), and produced rat pups that weighed more and had thicker cortexes than

the rat pups of the controls. Thus, the benefits of an enriched environment can last into old age and extend to future generations. New knowledge of the psychobiology of the brain has brought the environment inside the skull, a change that may finally erase the false dichotomy of nature and nurture. All environmental variables that affect the brain do so through biological mechanisms.

COGNITIVE NEUROSCIENCE: BRAIN-BEHAVIOR RELATIONSHIPS

Cognitive neuroscience walks a thin line. It must be exacting and build its foundation on the best and most stringent of observations about the mysteries of nature. On the other hand, it has to explore, in an intelligent and probing and verifiable way, how primary data speak to the issues of how brain enables mind.

—Michael S. Gazzaniga (1995, p. xiii)

Cognitive neuroscience is an interdisciplinary field of knowledge that combines cognitive psychology with the study of its neural substrate (underlying neural structures). It is an exciting field where new techniques for imaging the brain are rapidly advancing our knowledge. Cognitive neuroscientists study the relationship between the brain and behavior. Simply knowing that there are sex-typical patterns of performance on cognitive tests and seeing how male and female brains differ does not permit the conclusion that the brain differences are the cause of the cognitive differences or vice versa. In order to infer a brain-behavior relationship, we need (a) evidence that links those portions of the brain that differ by sex to sex-typical differences on cognitive tasks, and (b) a good theory (one that can be falsified) that predicts/explains the relationship. There are many studies described in this chapter that are bridging the gap between brain and behavior, providing both the data and the theory.

THE SEXUALLY DIMORPHIC BRAIN

Just, therefore, as higher civilization is heralded, or at least evidenced, by increasing bulk of brain; . . . so we must naturally expect that man, surpassing woman in volume of brain, must surpass her in at least a proportionate degree in intellectual power.

—*Popular Science Monthly* (1878–1879, cited in Russett, 1989, p. 16)

Many cognitive neuroscientists have been concerned with the question of whether there are differences in male and female brains, and, if so, whether these differences can be used to explain sex-related cognitive differences. Recall that the term “sexually dimorphic” refers to two different structures that vary as a

function of sex. In an influential article on this topic, Kimura (1987, p. 133) asked, “Are men’s and women’s brains really different?” Her simple answer is “yes, of course,” but the real questions are how, how much, and whether size differences have any meaningful relationship to cognitive abilities or behavior.

If we were to examine brains taken from females and males there would be no gross differences that could be used to identify the sex of their owner. Microscopic examinations of the structure of the nerve cells and nerve tissues that comprise the brain would show that the cells are morphologically identical except for visible X chromosomes (known as Barr bodies) in many of the nerve cells in women’s brains and Y chromosomes in the men’s nerve cells (Gersh & Gersh, 1981).

Although there are no gross anatomical differences in female and male brains, it is clear that there are some sex-related brain differences. Menstruation, for example, begins as a brain event with a hormonal feedback loop involving the pituitary and hypothalamus, which are brain structures. Certain between-sex synaptic differences are visible in the hypothalamus (as already explained), which could be a reflection of some or all of the many between-sex differences in reproduction, including the fact that women menstruate and men do not.

The picture becomes somewhat more complicated when we also consider that there are cortical neurotransmitters that function as sex hormones, indicating some between-sex cortical hormone differences (McEwen, 2007). Recall from the previous chapter that there are some differences in female cognition that vary across the menstrual cycle, but these differences are small and unlikely to be important in everyday life (Halpern & Tan, 2001). As you read about sex differences in the human brain, keep in mind the fact that male and female brains are more similar than they are different. Wahlsten and Bishop (1998) objected to the use of the term “sexually dimorphic” as a description of brains because it implies that there are two distinct forms of brains—one for males and one for females, which is certainly not true. There are some important differences, but they are all subtle and our knowledge of sex differences in the brain is still in its own perinatal period.

Size, Weight, and Complexity

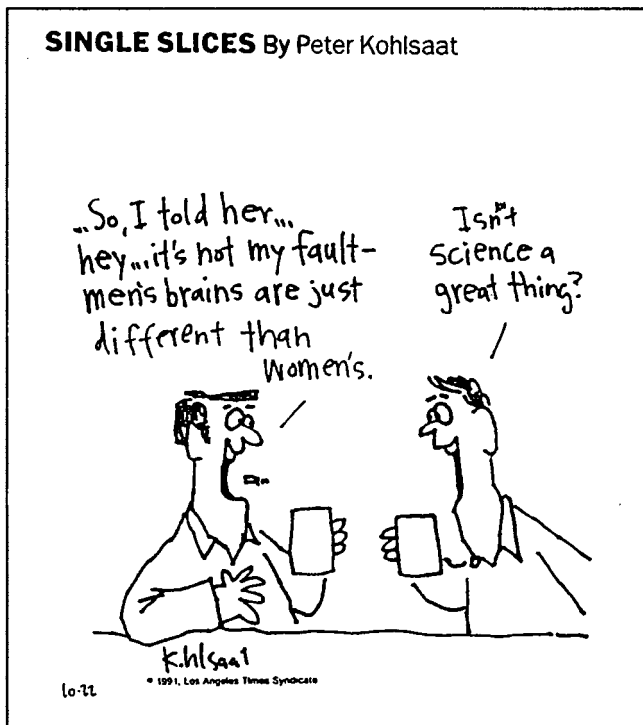
The assumption that bigger is better, as it applies to individuals of the same species has not survived the test of scientific examination . . . it may even be the case that paradoxically, less is better.

—Timothy K. Smock (1999, p. 187)

Early reports of differences between female and male brains parallel findings of Black and White racial differences. According to earlier theorizing, the supposedly inferior race and the supposedly inferior sex had similar brain deficiencies. Nineteenth century physicians warned that the female nervous system was delicate and not well suited for intellectual work. According to Burnham

(1977), these physicians claimed that both women and Blacks had “smaller brains with less capacity” (p. 10). One of the arguments for denying women and African Americans the right to vote was their purportedly inferior biology. Presumably, their smaller and less complex brains could not handle the complex decisions required of informed voters. The “theory” went even further in suggesting that intellectual endeavors would be bad for women’s health because the increased blood flow to the brain would drain the blood normally needed for menstruation.

In fact, women’s brains are somewhat smaller than men’s brains; male brains at birth are approximately 9–10% heavier and 2% larger in circumference than female brains (Janowsky, 1989), with general estimates of the size difference throughout life around 8–10% larger in males (Lenroot et al., 2007). But, this does not support the prejudicial position that females are inferior. I raised the question of brain size in [Chapter 1](#) where I introduced the concept of science in service to politics. Although the basic reasoning that “bigger must be better” when the topic is brains may seem simple-minded, it is important to think through the underlying assumptions, the data, and the implications of the



brain size question because it has been used for centuries as a means of justifying one group's superiority over another group.

Brain size and weight are positively correlated with body size. Since men, on average, tend to be larger than women, they also tend to have larger brains. In the first and second editions of this book, I concluded that when brain size was adjusted for differences in body size, the differences disappeared. Not surprisingly, whether or not the differences disappear when body size is used depends on how the adjustment is made. (The arguments over the correct way to adjust for body size are technical and not relevant to the discussion.) Although there is still considerable disagreement on this point, I now believe that small differences in brain sizes exist, even after body size is used to make the values more comparable (e.g., Gur & Gur, 1990). But, there is no evidence that larger brains are, in any way, better than smaller brains (within normal limits). If this hypothesis were true, then people with the largest hat sizes (reflecting greater brain sizes) would be the smartest. (In fact, I once debated this point in front of a large audience of scientists, where my opponent, a very large man, concluded by noting that his head was much bigger than mine, thereby proving his point. Naturally, it seemed to me that he had just shown that his hypothesis had been falsified.)

There are many ways to interpret the brain-size issue. As a species, humans do not have the largest brains or even the largest brain in relation to our physical size. Females and males score identically on IQ tests (with some studies showing small advantages for males, some showing small advantages for females, and others showing no differences, as reviewed in [Chapter 3](#)), and an independent analysis of tests that were written without concern for sex differences showed no overall difference in female–male intelligence (Jensen, 1998). Given that both sexes are equally intelligent on average, one could just as logically argue that female brains are superior because the smaller female brain has the same IQ power as the larger male brain. It would be like finding more intelligence per brain unit (or something like that). Jensen (1998) argued that the sex difference in brain size is best explained by the fact that neurons are packed more densely in female brains than male brains, resulting in a configuration that allows the same number of neurons in male and female brains despite differences in overall size. When we think about intelligence and the brain, we conceptualize the underlying hardware of intelligence as a complex web of interconnected neurons. Thus, it is not merely whole brain size, but the number and way in which neurons interconnect and communicate that is a primary determinant of cognitive ability.

Analyses of the evolution of the brain suggest that both body size and brain size are shrinking, with brain size shrinking faster than body size, at least over the last 25,000 years or so (Ruff, Trinkhaus, & Holliday, 1997). It may be that the shrinkage in brain size represents an efficient fine-tuning after a long period of rapid, and perhaps crude, increase in size. I liken this to the change in computers, which used to have very large central processing units—the “brain part”—and now have gotten much more powerful and much smaller. Regardless

of the reason, Gee (1997) concluded that brain size alone is not a particularly good measure of intelligence. It is more likely that certain portions of the brain, rather than the entire brain volume, would correlate with different measures of cognitive ability.

In a meta-analysis of 37 studies, McDaniel (2005) reported that there is a relationship between brain volume and intelligence, but the size of the relationship was different for females and males. Across both sexes, the correlation was $r = .25$, with a higher value for females ($r = .40$) and a lower value for males ($r = .34$). These numbers are somewhat misleading because the values came from different samples, which is why the average of the female and male samples is not close to the average for both sexes combined. This is an interesting finding, but there is no theoretical basis for expecting that brain volume would be a better predictor of intelligence for women than it would be for men. This is the sort of research outcome that is difficult to interpret because we have no explanation for sex differences in the relationship between brain volume and intelligence. Most other researchers report small relationships between brain volume and intelligence (Wallace et al., 2007). A more fine-grained analysis of size and intelligence relationship is needed to study brain regions that are known to be important for cognition. For example, there are fluid-filled ventricles in the brain that serve to cushion the brain in case of an accident, but there is no reason to believe that the size of the ventricles is related to intelligence.

The question of brain size becomes even muddier when we factor in research findings that show structural brain changes as a result of specific experiences. Consider, for example, a recent study in which adolescent girls (12 to 15 years of age) received 3 months of training (1.5 hours a week) with the popular computer game Tetris (Haier, Karama, Leyba, & Jung, 2009). In Tetris, different shapes appear to fall across the computer screen. The player learns to rotate each piece so that it completes a row at the bottom of the screen. Neuroimaging of the girls' brains before and after training showed increased cortical thickness and changes in regional blood flow (explained in the next section) relative to control participants that were associated with Tetris training. These large changes in structure and in blood flow resulted from a relatively small manipulation. We can only guess at the effects of years of sex-differentiated activities in creating or magnifying differences in the brains of males and females. The increase in cortical thickness means a (somewhat) heavier brain for the girls who had the Tetris training. Brain size and weight reflect sex differences in the average activities of girls and boys.

Recall earlier that one of the greatest achievements of the young brain is pruning—that is, eliminating neural connections that are not needed. The result is a lighter brain that is more efficient and more intelligent. Thus, there are neuroanatomical reasons to believe that smaller may be better. Studies of brain areas involved in advanced cognition show that experts use less neural space, so there is an efficiency that comes with expertise. This idea is seen in work on regional blood flow in the brain.

Regional Cerebral Blood Flow

Twenty-five years ago researchers in the field were engaged in an unedifying discussion of the relation between skull sizes and intelligence test scores.

—Earl Hunt, intelligence researcher (2007, para. 9)

Another way of measuring what is happening in the brain when individuals perform cognitive tasks is to monitor the rate of cerebral blood flow in different regions of the brain, a measure known as regional cerebral blood flow (rCBF). The basic idea in measuring the rate of blood flow is that blood is expected to flow fastest in areas of the brain where neurons are most active. Areas of the brain that are high in metabolic activity also “take up” (metabolize) more glucose, the energy supply for neuron firing. The brain needs a constant supply of oxygenated blood to function. Ruben Gur and Rachel Gur and their colleagues (Gur et al., 1982, 1991; Gur & Gur, 1990) have used rCBF measures in a series of experiments examining sex differences in cognition. A clear pattern of results emerged from these studies—women have a faster rate of blood flow per unit of brain weight than men when they are performing the same cognitive tasks. The Gurs believe that the higher rCBF in women compensates for their smaller brain volume. Thus, brain size is not meaningful unless it is considered in the context of other brain measures of brain functioning.

Key Structures

Gender is a major moderating variable in brain-function.

—Ruben Gur and Rachel Gur (1990, p. 247)

Several different areas in the brain have been identified for their sex differences in size, shape, or functioning. Brain regions with large numbers of hormone receptors are likely places to look for brain differences between males and females, as are regions that have been identified as likely areas for those cognitive abilities that usually show sex differences. The major areas are reviewed here, although keep in mind that how these areas interact with other areas may be more important than any area by itself.

Hippocampus

To date, no one has uncovered any evidence that anatomical disparities might render women incapable of achieving academic distinction in math, physics, or engineering.

—Larry Cahill (2005, p. 40)

Numerous studies with humans and other mammals have shown that the hippocampus is a brain structure that is crucial in many types of memory tasks,

especially visuospatial working memory. The hippocampus has large concentrations of receptors for sex hormones (Lenroot & Giedd, 2010; Wooley, 2007). In a classic book by O'Keefe and Nadel (1978), entitled *The Hippocampus as a Cognitive Map*, the authors made the case that the hippocampus builds cognitive maps that contain information about spatial relations. Its role in the formation of long-term memories is known to virtually everyone who has had an introductory course in psychology, where the story of H.M. is often told. H.M., the initials of one of psychology's best known case studies, had severe epilepsy. In an attempt to stop the debilitating seizures, he underwent brain surgery in the 1950s in which portions of his hippocampi (plural of hippocampus) and related brain structures were lesioned. The surgery worked in that the seizures stopped, but he was left with the unfortunate and unexpected side effect of being unable to create certain types of new long-term memories (Keane, Gabrieli, Mapstone, Johnson, & Corkin, 1995). The story is compelling because of the insights it provided into the way the brain stores memories and in the compassion for H.M. that it elicits from readers.

The hippocampus is a sexually dimorphic brain structure, which, as explained earlier, means that it differs in structure as a function of sex. In his review article entitled, "Why sex matters for neuroscience," Cahill (2006) wrote that there are sex differences in the structure and function of the hippocampus, with portions larger in women than in men, after adjusting for total brain size. The hippocampus also plays a role in estrogen feedback loops in women and is also influenced by testosterone concentrations (Juraska, 1991). The hippocampus is one area of the brain where sex differences in size are most often reported, with females having the larger size and showing more rapid growth during adolescence (Lenroot & Giedd, 2010). This finding is consistent with the fact that there is a greater density of estrogen receptors than androgen receptors in the hippocampus.

Hypothalamus

The hypothalamus is an important brain structure in the regulation of many biological and psychological functions. Many hormones or releasing factors for hormones are produced by the hypothalamus, which plays a primary role in the endocrine system. Structures in the hypothalamus secrete hormones that regulate menstruation in women via a cyclical pattern of hormone release, so it is obviously one brain structure that differs for men and women (Kalat, 1998). The hypothalamus is an important component in the regulation of emotion. Neurons project from the hypothalamus into many other brain regions, including the frontal cortex, so it is likely that it is also important in some cognitive tasks. As mentioned earlier in this chapter, there is a dramatic sex difference in one portion of the hypothalamus, which is larger in males. One

cell group in this area is involved in masculine behavior. (It has been studied in rats, humans, and other mammals.) As described earlier, in humans, this cell group (INAH-3) is smaller in homosexual men than heterosexual men (LeVay, 1991). Sex and possible sexual-orientation differences in the hypothalamus are discussed later in this chapter in the section on sexual orientation and the brain.

Amygdala

The striking sex differences in amygdala function at rest imply that all studies of human amygdala function—not just those concerned with memory—should consider potential sex influences.

—Joseph M. Andreano and Larry Cahill (2009, p. 260)

The amygdala is a subcortical structure that is shaped like an almond. It plays a key role in emotional memory and emotional responses. Many studies have found that women have better memory for emotional events (Canli, Desmond, Zhao, & Gabrieli, 2002). The amygdala has strong connections to the hypothalamus (Lenroot & Giedd, 2010), which is a key brain structure in signaling the release of sex hormones (as explained in [Chapter 4](#)). The amygdala is typically larger in males, which is related to the finding that there is a greater density of androgen receptors than estrogen receptors in this brain structure. The amygdala has also been associated with disorders such as depression and anxiety, which occur much more often in females than in males (Becker & Grilo, 2007).

There are amygdalae in the right and left hemispheres of the brain. When recording from the brain, there is a spike in brain activity that occurs 300 milliseconds (0.3 second) after viewing disturbing pictures. This rapid brain response occurs before anyone has conscious knowledge of what they are seeing. This spike (called the P300) is larger in the right hemisphere for men and in the left hemisphere for women (Cahill, 2005). These results have led researchers to conclude that amygdala activity in response to emotional events is left lateralized for women and right lateralized for men (Canli et al., 2002). It also seems that in women, the amygdala acts in concert with the hypothalamus, which directs the stress response. By contrast, the amygdala acts in concert with the motor and visual areas of the brain in men. Other researchers have found that memory for an emotional event involves the amygdala. Women have better memories for emotional events than men do. Women also suffer from anxiety disorders, specifically post-traumatic stress disorder (PTSD) that is associated with traumatic events, about twice as often as men. It is possible that sex differences in the amygdala may partly account for the greater prevalence of PTSD in women, although it is still a long leap from brain structures to behaviors and emotions (Hamann, 2005).

SEXUAL DIMORPHISM IN HEMISPHERIC SPECIALIZATION

If there is one unifying theme . . . it is that the direction for future research in lateralization of function lies in exploring how the hemispheres act as complementary processing systems and integrate their activities.

—Marie T. Banich and Wendy Heller (1998, p. 1)

All of the major theories of sex differences in cerebral organization begin with a simple analogy. Given that the types of abilities that differ by hemisphere of specialization are the same ones that differ by sex, it seemed to many psychologists only a short leap to suggest that the sexes differ in the way their hemispheres specialize these abilities. The logic behind this reasoning is that since sex differences are primarily found with verbal and visual-spatial tasks and that hemispheric specialization differs with respect to these two abilities, then it is plausible that there are sex differences in cerebral lateralization. The question being posed here is “Are female and male brains different in the way the hemispheres are lateralized (or specialized) for cognitive tasks?” A large body of research has revealed that the two hemispheres or halves of the brain are, to some extent, lateralized or dominant for different cognitive functions, possibly as a function of the corpus callosum. But, what does it mean to say that one hemisphere is dominant with respect to a cognitive ability? According to Geschwind (1974), “One hemisphere may be said to be dominant for a given function when it is more important for the performance of that function than the other hemisphere” (p. 9). Hemisphere dominance does not mean an either/or division of tasks. It means instead that one half of the brain is more or less specialized or proficient in its ability to process certain types of stimuli. The popular idea that there are right-brained and left-brained people is oversimplified.

There is a surprisingly large research literature on the question of sex differences in laterality, which is an indicator of sex differences in cerebral dominance. More recent studies, which have tended to use larger samples and a variety of imaging techniques and cognitive tasks, have concluded that “no simple and universal relationship exists between behavioral asymmetry and anatomy of the corpus callosum” (Welcome, Chiarello, Towler, Halderman, Otto, & Leonard, 2009, p. 2434). Other researchers have concluded that differences in brain lateralization are not likely to be important in understanding cognitive sex differences (Sommer, Aleman, Bouma, & Kahn 2004; Wallentin, 2009). Thus, earlier conclusions about sex differences in lateralization of cognitive abilities are most likely wrong.

One brain area that has been extensively studied with regard to the question about sex differences in lateralization is the corpus callosum, the broad band of axons that connect the two hemispheres.

Corpus Callosum

The past 15 years have witnessed an explosion of research on sexual dimorphism in the human corpus callosum.

—Elizabeth Hampson (1998, p. 331)

The corpus callosum is composed of 200 to 800 million nerve fibers that transfer information between the right and left hemisphere; it is the primary pathway for communication between the two halves of the brain. It is the largest fiber track in the brain, and it is made up, almost exclusively, of axons. There is a voluminous research literature examining the question of whether this large band of neural fibers differs in shape, size, or some other significant way between females and males. The reason for all of the interest in the corpus callosum is that a major theory of sex differences in cognitive abilities maintains that the sexes differ in the way the two hemispheres are specialized for cognitive tasks, but as concluded in the last section, this theory has not been supported, so even if there are sex differences in portions of the corpus callosum, these differences have little or no effect on the lateralization of cognitive tasks.

The corpus callosum is a difficult structure to study because of its irregular shape. Until recently, data about the corpus callosum came from autopsies. Now that MRIs are more routinely available, we can study this important brain structure in normal, healthy people. There is much interest in the question of whether different hormones, prenatally or at other periods in the life span, can be related to the size, shape, or integrity of the corpus callosum. Of course, it is unethical to deliberately manipulate hormone levels in humans, so the types of experimental studies that permit causal statements (e.g., hormone levels and types cause size differences in the corpus callosum) necessarily rely on research with nonhuman mammals. Correlational data from humans (e.g., correlations between the size of a particular area of the corpus callosum and scores on tests of spatial ability) can provide corroborating evidence.

One experimental approach is to vary hormone levels in developing nonhuman mammals and then determine if the hormones that were manipulated had an effect on the corpus callosum. Using this approach, investigators have found that if they administer testosterone to newly born female rats, the corpus callosum becomes larger—a typical male rat brain finding which differs from the human brain. When pregnant female rats are given an anti-androgen, the size of the corpus callosum of their male offspring becomes smaller—a typical female rat brain finding (Denenberg, Berrebi, & Fitch, 1988; Fitch & Denenberg, 1998). Researchers also found that ovarian hormones are important in determining the overall size of the corpus callosum, a result that shows that ovarian hormones are important in brain development. It seems clear that for rats, the corpus callosum is larger in the male and that the size differences are probably caused by prenatal sex hormones. This research is particularly

important because it provides causal evidence that ovarian hormones play an active role in organizing the fetal brain in a female direction.

Of course, studies of rodent brains are not directly generalizable to humans, and although we expect the general principle that sex hormones affect brain development to be similar, the exact effects of hormones may not be the same. Research with humans has generally shown that there are sex differences in the shape and probably the volume of selected portions of the corpus callosum (e.g., the splenium), with females, in general, having a larger and more bulbous structure (Liu, Vidarsson, Winter, Tran, & Kassner, 2010; Steinmetz, Staiger, Schlaug, Huang, & Jancke, 1995), a result that was first reported by de Lacoste-Utamsing and Holloway (1982). Many studies have concluded that “women (have) larger corpus callosa (plural of callosum) relative to cranial capacity than men” (Johnson, Pinkston, Bigler, & Blatter, 1996, p. 408). These authors criticize studies that have not found differences as having too few subjects or failing to control for overall head size. The conclusion that women have a corpus callosum that is larger than it is in men is important because it supports the idea that females may have better connectivity between their cerebral hemispheres (Innocenti, 1994), or may transfer information at a higher rate of speed (Jancke & Steinmetz, 1994).

Hines and her colleagues (Hines, Chiu, McAdams, Bentler, & Lipcamon, 1992) studied the relationship between the size of specific regions in the corpus callosum (i.e., the spleniums) and performance on a variety of cognitive measures. They concluded that (within women) larger spleniums are associated with higher verbal fluency scores. Hines argued that a larger corpus callosum may be associated with better interhemispheric transfer of information, which contributes to verbal fluency. In other words, she argued that females may be better than males in verbal fluency *because* females have a larger and more efficient corpus callosum. More recent research using sophisticated methods of measurement do report sex differences in small portions of the corpus callosum (Luders, Thompson, & Toga, 2010), but it is a long leap to infer that these differences, which are relatively small and appear to follow a somewhat different developmental trajectory, *cause* any cognitive difference such as verbal fluency. There may be small differences, accounting for about 0.9% of the variance, but with values this small, sex differences in the corpus callosum are not a meaningful variable (Boles, 2005; Haut & Barch, 2006; Liu, Stuffelbeam, Sepulcre, Hedden, & Buckner, 2009). Moreover, some neuroscientists believe that any sex differences in the corpus callosum probably reflect sex differences in overall brain size (Leonard et al., 2008).

It is probably difficult for most readers to understand how much controversy has been generated over the question of whether the corpus callosum differs between men and women. In an earlier paper on this question, I wrote, “the debate over sex differences in the corpus callosum is more often acrimonious than scholarly” (Halpern, 1998, p. 330). This summary of the field should suggest that there are researchers who do not agree with the conclusion about sex differences in the corpus callosum. Interested readers will enjoy a section

of the journal *Behavioral and Brain Sciences* (1998, volume 21) where scientists fight about (oops, I meant debate) this question.

A newer way of measuring the size of the corpus callosum may help to clear up some of the confusion. It is called TDM, which stands for template deformation morphometry (Halpern, Benbow, et al., 2007a) With TDM each person's callosum is compared to a standard template. Using this method, several different studies reported that one area of the callosum, the splenium, is larger in women than in men on average (e.g., Dubb, Gur, Avants, & Gee, 2003). Even if this relationship holds up over repeated studies, we have no direct evidence to conclude that differences in this section of the corpus callosum underlie sex differences in cognition. Part of the complexity in understanding sex differences in the corpus callosum is that differences vary as a function of age, which may be why different studies are inconsistent (Lenroot & Giedd, 2010).

The research reviewed in this chapter provides strong evidence for the conclusion that there are sex differences in the human brain that underlie cognition, although we are a long way from understanding the differences between females and males in the organ that is responsible for all we know and do. This area of research is fraught with multiple problems—contradictory findings among researchers, long leaps from brain anatomy to cognition and behavior, and the established fact that brain anatomy reflects behavior so any differences could be attributed to differential life experiences for males and females.

ESSENTIALIZING THE DIFFERENCES IN FEMALE AND MALE BRAINS

Gender differences were merely the first indication that not all brains work the same way.

—Richard J. Haier (2009, p. 31)

Considering all of the evidence we have reviewed, what can we conclude about male and female brains? The take away message is that there are sex differences in the brain, but the brains of females and males are far more similar than they are different. Giedd (2005), a researcher at the U.S. National Institutes of Health, is the leading authority on sexual dimorphism in the developing brain. At a presentation he made on this topic at the U.S. National Academy of Sciences, Giedd explained that nearly all neuropsychiatric disorders of childhood differ between girls and boys in terms of their age of onset and symptoms, but the differences reflect environmental and genetic factors acting together. He responded to the question of whether brain size matters in typical researcher style, with “No, but.” The “no” part of the answer was based on the finding that people across a broad range of brain sizes have similar cognitive abilities. The “but” part of his answer came from a few studies that found “modest” relationships between IQ and total cerebral volume; he concluded

that it is possible that there is a relationship between the size of the hippocampus and memory, but gross measures of overall brain size are less likely to be meaningful. If you have been reading carefully, you already know that even modest findings that relate brain size to IQ are likely to have been caused, at least in part, by differences in experience.

Empathizers and Systematizers

There is also nothing new about looking to the brain to explain and justify the gender status quo.

—Cordelia Fine (2010, p. xxiv)

Not all researchers are as careful as Giedd in considering the way experience shapes the brain. Baron-Cohen (2004), for example, maintains the position that male and female brains are “essentially” different. Baron-Cohen studies autism, which is a developmental disorder that is usually diagnosed within the first two years of life. Like most mental disorders, autism has a wide range of symptoms, with some people showing profound deficits and others functioning closer to normal behavior. Children and adults with autism tend to have poor social skills, rarely make eye contact, and may fixate on some objects, such as repeatedly pouring sand from one container to another. Other symptoms may include delayed speech; some children with more profound autism will not speak at all. Others will continually repeat words or phrases that they hear, which is known as echolalia. Autism is four times more common in boys than in girls, a pattern that seems to be found worldwide (Autism Society, 2009).

The large sex ratio in the number of males and females who are diagnosed with autism suggests that there is something in the prevalence of this disorder that is linked to sex. Baron-Cohen hypothesized that autism is an “extreme male” brain (apparently even when it occurs in females). He based this conclusion on several pieces of evidence. His primary evidence is one study that was conducted with newborns in which he found that girl babies preferred to look at faces, especially people’s eyes, and boy babies preferred to look at inanimate objects (Connellan, Baron-Cohen, Wheelwright, Batki, & Ahluwalia, 2001). He also relied on data such as results from individuals with congenital adrenal hyperplasia (CAH), which as explained in the previous chapter, refers to children who are exposed to high levels of testosterone prenatally, a condition which tends to masculinize girls, and the general finding that more males go into careers that are related to science and math and more females go into careers in the helping professions. These two career-related findings are discussed in more detail in the following chapters. Baron-Cohen’s basic distinction is that boys’ brains are best suited for “systemizing,” which makes males better in science and math, and girls’ brains are “empathizing,” which makes females better suited for child care and other caring professions.

Numerous researchers have offered stern criticisms of the idea that female and male brains are “essentially different,” especially in ways that Baron-Cohen has suggested (e.g., Eliot, 2009; Spelke & Grace, 2007). According to Baron-Cohen, it is high levels of prenatal testosterone that make the male brain good at systemizing. But males who are exposed to very high levels of testosterone while still in the womb (i.e., CAH males) are not more masculine or better at male-typical tasks than males who are exposed to normal levels of prenatal testosterone. In fact, the idea that high levels of prenatal testosterone cause autism, which might be expected from this theory, has not been supported. In addition, one prediction from this hypothesis is that autistic boys would be “hypermasculine,” which is not supported with any research (Eliot, 2009). The experiment with newborns that Baron-Cohen frequently cites as evidence that girls are born with an interest in faces and boys are born with an interest in objects has been criticized on methodological grounds, including experimenter bias, small sample size, and failures to replicate (Spelke, 2005). (All of these topics were discussed in [Chapter 2](#) where I explained that it is critical to be able to discern the difference between good and poor research if you want to follow the various arguments related to cognitive sex differences.) In addition, numerous studies have found no sex differences in aptitude for science or mathematics in young children (Fine, 2010). Thus, the idea that female and male brains are essentially different and these differences explain why there are more males in the physical sciences and more females in helping professions does not hold up to additional scrutiny.

SEXUAL ORIENTATION AND THE BRAIN

Differences related to sex and sexual orientation are important aspects of human diversity, well worth studying regardless of the supposed benefit or harm that such research will bring.

—Simon LeVay (1996, p. 284)

In [Chapter 4](#), I provided a brief overview of research that found that gay males often perform worse than heterosexual males on visuospatial tasks and lesbians perform better than heterosexual women on these same tasks (judgment of line orientation and mental rotation tasks; Collaer, Reimers, & Manning, 2007; Peters, Manning, & Reimers, 2007). The large and rapidly growing body of research into this fascinating area was summarized in [Chapter 4](#), which suggests a more female-typical cognitive pattern for gay males and a more male-typical cognitive pattern for lesbians. Of course, readers are once again reminded that these are group averages, and there is considerable variability within groups.

Brain Correlates of Sexual Orientation

Reviews of the relationship between preferred hand and sexual orientation found that homosexual men and women are more likely to be left-handed than

heterosexuals (Lalumiere, et al., 2000; Lippa, 2003). Although most people (homosexual and heterosexual) are right-handed, gays and lesbians have 39% greater odds of being left-handed (the term non-right-handed is usually preferred; Lalumiere et al., 2000). These findings were replicated in the large internet study of sex and cognition, with left (and mixed)-handedness associated with homosexuality in both men and women (Blanchard & Lippa, 2007). These results suggest an “early neurodevelopmental” determinant for sexual orientation (Lalumiere et al., 2000, p. 575). Given that handedness is an indicator of cerebral dominance, gay men and lesbians are more likely to be highly lateralized for cognitive tasks, in other words, they are more likely to be more specialized for different tasks in each hemisphere of their brain; it is also likely that these effects, if they exist at all, are relatively small. Based on experimental work with nonhuman mammals, Kerchner and Ward (1992) hypothesized that prenatal hormones are important in the development of a wide range of sex-typical brain organizations and sex-typical behaviors, with strong evidence of their role in determining sexual orientation. Kerchner and Ward (and others) believe that prenatal stress attenuates the surge in testosterone that is critical for male development during the prenatal period. In addition to affecting sexual orientation, the attenuation of testosterone is hypothesized to negatively affect the left hemisphere, which matures more slowly than the right, which increases the incidence of left-handedness (as hypothesized by Geschwind and Galaburda and explained in [Chapter 4](#)). The decrease in testosterone may also result in incomplete masculinization of the POA, the tiny brain structure that, as noted earlier, was found to be smaller in homosexual males than in heterosexual males. This is a good example of an environmental variable, stress, working through biology, thus demonstrating once again how the biopsychosocial model underlies the link between cognition and sex.

Of course, brain structures do not directly *cause* any particular sexual orientation; they are correlates of sexual orientation that may reflect prenatal and early life hormones that interact with a lifetime of environmental experiences to make each of us the person that we are. The environmental effects are also complex. For example, Green, Roberts, Williams, Goodman, and Mixon (1987) found that a disproportionately high number of gay men engaged in female-typical play as children. More often than their heterosexual counterparts, gay men played with dolls, role-played as females (e.g., dress-up), and avoided male-typical rough and tumble play. Thus, on average, the gay men had many female-typical childhood experiences, presumably self-selected, that made up their childhood experiences. If you are reading these chapters in order, then you probably recall studies of females who received high levels of adrenal testosterone prenatally. These CAH females also engage in play activities that are more typical of male play behavior, so their early hormone environment affects many life choices and experiences (Berenbaum, 1999). Brain structures and functions can vary as a result of experience, making it impossible to disentangle all aspects of our biology and life experiences, although

particular relationships can be discovered and future technology may provide insights not now imagined.

CRITIQUE OF BIOLOGICAL HYPOTHESES

Should society halt research that generates such knowledge?

—Morton Hunt (1999, p. 347)

Why are so many people opposed to any biological theory of cognitive sex differences? Perhaps we can understand some of the intense emotions generated by biologically based theories by examining their weaknesses.

Biological and Environmental Interactions

Sex-related brain differences result from pre- and postnatal hormone levels, *and* they are influenced by sex-differentiated patterns of socialization. Most of the biological theories discussed in this chapter have either failed to consider or have downplayed the fact that biology and the environment interact, although there is a growing recognition that researchers must take both types of influences into account in their studies. For example, although it is possible that males are better at spatial skills because their cerebral organization is more lateralized than that of females, it might also be possible that *because* males excel at spatial skills or perform them more frequently, their hemispheres develop a more lateralized organization. Similarly, we know that young girls receive more verbal stimulation and are encouraged to read and speak correctly. (These data are described more fully in the next chapter.) Their early reliance on verbal skills could cause verbal skills to be developed at the expense of other types of abilities such as spatial skills. Although the possibility that life experiences influence biological processes such as brain lateralization must be considered, it is also clear that biology influences the types of experiences to which people are exposed. For example, if boys are better than girls at visuospatial tasks for biological reasons, parents could differentially encourage this ability by buying them spatial toys (e.g., puzzles, building toys) which in turn provide them with more experience with spatial manipulations than their sisters would receive. Keep in the mind the strong effects that environmental variables have on brain structures, which turns the argument that sex differences in the brain *cause* sex differences in behavior on its head. The reverse may also be true.

We have considerable evidence that today's young women are better at visuospatial tasks than previous generations of women. Women have been entering traditional academic fields that require these skills at increasing rates over the past twenty years. Almost all engineering and architecture schools report that the proportions of women have increased substantially since the

Women's Movement began in the 1960s, although the percentage of women in engineering and physics still remains low.

On the other hand, psychosocial variables cannot account for all of the sex differences data presented in [Chapters 4](#) and [5](#), which considered genes, hormones, and brains—all of which differ in important ways that would be expected to produce sex differences in a variety of behaviors. Some of the strongest data are the recent findings that the administration of sex hormones to healthy adults can improve some types of cognitive skills, depending on which hormone is administered. Recall the finding that a single dose of testosterone improved visuospatial skills for young women (Aleman, Bronk, Kessels, Koppeschaar, & van Honk, 2004) and the finding that estrogens can reverse or exacerbate the ravages of Alzheimer's disease in older women, depending on when they are administered (Coker et al., 2010). Hormones and genes clearly play an important role in understanding cognitive sex differences.

The Notion of Optimal Cerebral Organization, Optimal Hormone Balance, and Optimal Genetic Configuration

Complex cognitive tasks are multidimensional in nature, so there can be no single optimal cerebral organization, best hormone balance, or optimal genetic pattern, although there may be several optimal configurations. Consider the fact that male and female brains differ along several dimensions, with the smaller female brain composed of more densely packed neural units, and having higher regional cerebral blood flow. Size cannot be considered without reference to all of the other systems and structures that reflect brain action. Single dimensions cannot be used in understanding systems in which multiple components interact. Although there are regions of specialization in the brain, it is also true that the brain operates via networks that communicate across multiple brain regions, so current attempts to separate brain functions will always fall short on capturing the interactive nature of multiple regions of the brain.

Intervening Variables

It is also possible that biology affects the development of cognitive skills in indirect ways that are generally not considered by proponents of the biological theories. Suppose that males tend to be more active because of higher levels of prenatal hormones. Individuals who are more active might be expected to develop better spatial skills because they move around the environment more often, roam farther at an earlier age, and interact with more objects. Thus, there could be biological reasons for sex differences in cognitive abilities, but they could be different from those being investigated.

A second intervening variable that could mediate between biology and environment is body type. Consider the notion that early maturing adolescents have poorer visuospatial skills than late maturing adolescents (Waber, 1976, 1977). As Waber pointed out, early maturing adolescents may not only have different patterns of cerebral lateralization, they also have different social environments. Shapely seventh grade girls and tall muscular seventh grade boys are responded to differently than their less developed peers. Social differences in response to mature body types could cause early maturing boys and girls to consider their math and science classes less seriously and create or increase differences in these areas that correlate with maturation rate. Support for these hypotheses is examined in the following chapter.

Body type is also a likely intervening variable for individuals with genetic or hormonal abnormalities. Much of the research in this area has used women with Turner's syndrome to support or refute biological arguments. Although these women clearly appear female, they have unfeminine body types (small breasts, thick necks). Their body type could cause them, consciously or unconsciously, to exaggerate feminine traits because they tend to look "unfeminine," which could include eschewing stereotypically masculine cognitive skills. It does seem likely that women with Turner's syndrome sought certain experiences that would help them adjust to their body type. It is difficult to know how these special experiences affected their cognitive growth.

Differences and Deficiencies

It may be no benefit to society to assume that the two sexes are basically homogeneous with respect to cognition and that the only heterogeneity is that imposed by different experience. Zero variation is not a requirement of equal opportunity.

—Sandra Witelson (1988, p. 217)

Many people are concerned that if we concede that there are sex differences in the "underlying hardware" of human thought, then those who are anxious to keep women out of nontraditional occupations will use this finding to justify discrimination. Weisstein (1982) offered a stern caveat when she said, "Biology has always been used as a curse against women" (p. 41). It is important to keep in mind that sex differences are not synonymous with sexism. The empirical research that has been reviewed in this chapter is not anti-female. It is neither misogynist nor antifeminist to report that, on the average, males have superior visuospatial ability and females have superior verbal ability and that some of these differences could be biologically based. It could even be argued that these results are more pro-female because verbal abilities are needed in every academic field and every endeavor in life, and females, on average, demonstrate higher verbal abilities for important real-world tasks like verbal fluency, spelling, and writing.

It is also important to keep in mind that while the major focus of this book and research in this area is on sex differences, similarities are more often the rule. In McGlone's (1980) review of the cerebral asymmetry literature, she concluded, "Thus, one must not overlook perhaps the most basic conclusion, which is that basic patterns of male and female brain asymmetry seem to be more similar than they are different" (p. 226). Even though McGlone's review is several decades old, the basic conclusion about similarities remains true. Perhaps the most striking finding from all of the neuropsychological research is the overwhelming number of similarities between the sexes and the relatively few sex differences that have emerged.

We know that there are sex differences in cognitive abilities, sex hormone concentrations, and the relative concentration of gray and white matter. There are also indisputable sex differences in the reproductive organs and genitals. No one would argue that either sex has the better reproductive organs or genitals. They are clearly different, but neither sex would be considered deficient in these biological organs. However, when cognitive differences are considered there is sometimes an implicit notion that one sex will be found better than the other. Is it better to be high in verbal skills or visuospatial skills? This is a moot question. The answer depends on the type of task that needs to be performed, the quantification of how much better, and individual predilection. To argue that female hormones are better than male hormones or that male brains are better than female brains is as silly as arguing which sex has the better genitals. Neither sex has the better biology for intellectual ability. When it comes to biological explanations for cognitive processes, we still have more questions than answers. It remains the task of future scientists, both females and males, to ask questions and formulate answers about the mutual influences of biology and cognition.

CHAPTER SUMMARY

Gonadal hormones play an important role in the development and organization of the brain. Although hormones affect brain functioning and neuroanatomy throughout the life span, the most critical periods are during prenatal development when the brain is forming, infancy when neural connections are forming at high rates of speed, puberty when excess neural connections are pruned, and late life when the brain is reducing in overall volume. New brain research has shown that ovarian hormones are important in determining how the brain develops and functions. Recent research has also recognized that experience can shape and alter some brain structures and functions. The finding that female and male brains differ in some ways highlights issues about the interplay of biology and environment.

Cognitive neuroscience is a burgeoning field of study where performance on cognitive tasks is related to brain activities and anatomy. New imaging

techniques are allowing scientists to study humans as they perform cognitive tasks. This is an exciting field that is casting new light on our understanding of the brain. Cognitive neuroscience is revealing between-sex differences in many brain systems, including rate of regional cerebral blood flow, areas of brain activated during cognitive tasks, and size and shape of some brain structures.

For the last 100 years (at least), some scientists have argued that women have smaller and therefore inferior brains. This size argument has been used with other groups, including African Americans, to justify discrimination. The idea that brain power is directly proportional to overall brain size is oversimplified. Given that females and males achieve the same scores on standardized intelligence tests, the small size argument is clearly wrong. The use of science in service of social agendas is one reason why the study of sex differences is so controversial. Just as modern computers are both smaller and more powerful than earlier models that were large and relatively slow, there is no reason to expect a relationship between overall brain size and intelligence.

Human brains reflect the adaptive pressures of evolution. Not surprisingly, many have suggested that the division of labor in hunter-gatherer societies caused sex differentiation in the way the brain developed. It is undoubtedly true that our brains are the product of evolution, but more direct evidence linking modern sex differences in cognition to brain changes that resulted from this early division of labor is tenuous, at best. Information about “what” an object is and “where” it is located are processed separately in the brain. We do not yet know if there are sex differences in the way these two systems operate. This is a fruitful area for future research.

Recent findings that women have a higher proportion of gray matter and men have a higher proportion of white matter do not relate directly to sex-differentiated patterns of cognitive abilities. The finding that white matter correlates with intelligence in women and gray matter correlates with intelligence in men is interesting, but like the other findings of sex differences in the brain, we still need replications and more empirical observations to formulate theories to answer the important “why” questions.

Anatomical differences between the sexes are found in some regions of the brain that underlie cognition, in addition to those differences that underlie the biology of reproduction. These structures include the hippocampus, hypothalamus, amygdala, and perhaps one portion of the corpus callosum. A major theory of sex-related brain differences concerns the specialization of each cerebral hemisphere for cognitive tasks. Although this is an area of intense disagreement, the overall evidence is weak and recent failures to replicate findings have led many researchers to conclude that it is false (e.g., Eliot, 2009).

Gay males and lesbians differ from heterosexual males and females on some cognitive tasks that usually show sex differences. On average, gay males show more female-typical performance and lesbians show more male-typical performance on some visuospatial tasks. We also know that there are some brain

differences between gay and heterosexual males; however, there are no direct links showing that the anatomical brain differences between heterosexuals and gays and lesbians can explain performance on the cognitive tasks. The increased likelihood that lesbians and gays are left-handed relative to heterosexuals suggests some sexual-orientation-related differences in cerebral dominance as well as an early neurodevelopmental origin for sexual orientation, but it is important to keep in mind that the majority of gays and lesbians, like the majority of heterosexuals, are right-handed.

Finally, our current knowledge of biological–cognitive linkages remains sketchy and largely incomplete. Even those theories that have received empirical support remain open to criticism on logical and methodological grounds. Interpreting sex differences as cognitive deficiencies for either sex is not justified, but the study of differences is justified as this research may help to reveal how brains work and how they sometimes fail to work.

Psychosocial Hypotheses

Part I: Sex Role Stereotypes Throughout the Life Span

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May you be the mother of a hundred sons.

—traditional Indian blessing (and title of a book by Bumiller,
1990, that depicts the life of Indian women)

If you have been reading the chapters in order and just finished the preceding two chapters that examined genetic, hormonal, and brain-based hypotheses about sex differences in cognition, you probably spent much of the time considering alternative hypotheses. Whenever I teach this material to college

classes, I always find that there are students who simply cannot wait to point out the ways in which differing life experiences for males and females could be used to explain the data. Hypotheses that favor the nurture side of the nature–nurture controversy will be considered in this and in the following chapter. When thinking about the way environmental variables influence how males and females think, keep in mind the biopsychosocial framework that is used throughout this book. How might biological differences between the sexes be contributing to societal expectations, and how might societal expectations be creating or increasing cognitive sex differences? These two approaches will be synthesized and conclusions about the relative merits of each will be presented in the concluding chapter.

GENDER AS A SOCIAL CONSTRUCTION

Gender depolarization would . . . require a *psychological* revolution in our most personal sense of who and what we are as males and females, a profound alteration in our feelings about the meaning of our biological sex.

—Sandra Lipsitz Bem (1993, p. B2)

Before you left your home this morning, did you smear a waxy, colored substance over your lips? Have you ever shaved the hair on your legs? Do you carry books with your arm extended down your side (as opposed to close to your chest)?

Based on how you answered just these three questions, I could make a pretty good guess about whether you are a woman or man. Of course, there are some men who wear lipstick and shave their legs (some swimmers shave their legs to reduce “drag”), and many women who do not wear lipstick or shave their legs (especially if we consider a world perspective), but if you answered “yes” to the first two questions, I would most frequently be right in guessing that you are a woman. Similarly, if you said that you carry books with your arm extended, you are probably a man. There is nothing about the biological bases of sex that dictates who wears lipstick, shaves their legs, or carries books in a particular way. These sex differences are societal manifestations of sex—that is they are social constructions. As already noted, proponents of the view that sex differences that are unrelated to reproduction are created by society often prefer to use the term “gender” to emphasize the distinction between biological and sociological. As Crawford, Chaffin, and Fitton (1995) explain it, “*Gender* is what culture makes out of the ‘raw material’ of biological sex” (p. 341).

Some of the social constructions of sex are so ingrained in our society that we have come to think of them as “natural,” that is, part of the nature, not the nurture, of being male or female. This point of view is called “essentialism” because it is based on the idea that sex differences (unrelated to reproduction) are an essential component of being male or female. It is only by examining

societies that are different from our own that we come to recognize that wearing make-up or shaving the hair off one's legs is not inherent in being female. Cross-cultural comparisons of cognitive sex differences show both transcultural similarities and important differences. Much of the data available from countries around the world was summarized in [Chapter 3](#), where the data in support of the conclusion that there are sex-related cognitive differences were presented. For example, similar conclusions about sex differences in cognitive abilities were obtained from the international samples that participated in the BBC study of sex differences. Recall that researchers (Lippa, Collaer, & Peters, 2010) found a male advantage on mental rotation in 53 countries, although the size of the difference between the sexes varied among countries—a fact that I return to discuss in [Chapter 7](#). Using the same data set, international sex differences were also found favoring women for memory for the location of an object and for category fluency (naming as many members of a category, for example, furniture, as possible in one minute; Maylor, Reimers, Choi, Collaer, Peters, & Silverman, 2007). The advantage of these large international studies is that it is possible to obtain large samples from countries that were historically underrepresented in published research. Two important conclusions arise from large international studies of cognitive sex differences: (a) cognitive sex differences are found throughout the world, and (b) the size of the differences varies depending on cultural variables.

The Importance of Psychosocial Variables

Gender is a complex variable because men and women differ not only biologically, but also in their life experiences.

—Ellen Leibenluft (1996, p. 163)

There can be little doubt that environmental and social factors play a major role in the cognitive development of every member in our society. The crucial question for the purpose of understanding cognitive sex differences is, “How, how much, and when, in the life span, do the socialization practices and other life experiences that differ for males and females influence the ability to perform intellectual tasks?” Of course, this question is based on the assumption that life experiences differ in systematic ways depending on biological sex. I have found that some people are willing to accept this assumption at face value, taking it as a statement of the obvious, and eager to consider the ramifications of these differences. Others, however, believe that sex-differentiated socialization practices are a “thing of the past.” Advocates of this point of view believe the magazine and billboard ads that proclaimed, “You’ve come a long way baby!” The underlying message is that contemporary women do the same sorts of things that men do, and sex-related differences in life experiences are either inconsequential or nonexistent. It is ironic to note the subtle influence of language as typified in this slogan that supposedly announced sexual equality.

If women had, in fact, “come a long way,” then they would not be referred to as infants or children, just as Black men are no longer called “boy.” These ads, which you probably recognize, were designed to sell cigarettes. The incidence of lung cancer among women is now almost as high as that of men. The ad is correct with respect to lung cancer. Women have come a long way, but in this case, in the wrong direction.

If anyone doubts that women and men still tend to live sex-segregated lives in contemporary American society, a casual visit to a Parent Teacher Association (PTA) meeting, or the restaurant in a large department store midweek, or a trade union hall, or a corporate engineering department will attest to the fact that while changes in the societal roles of women and men are occurring, there are still considerable differences in men’s and women’s experiences. High school cheer leaders are still virtually all female, while shop classes remain virtually all male. Few girls play in the now “coed” little league games (especially in the high school leagues), and few boys elect to take home economics classes.

An important part of understanding differences between any groups is to look at how they spend their time. There is a large research literature on how people become experts in any field. Do you know this old joke? A man is stopped on the streets of Manhattan and asked, “Do you know how to get to Carnegie Hall?” (an elite concert hall in New York). He responds, “Practice, practice, practice.” Expertise in any field, whether it is solving problems in physics, creating beautiful music, or becoming an expert surgeon, requires extensive practice (Ericsson, 2007). How much practice is needed? K. Anders Ericsson, a leading researcher in the field of expertise, estimated that for musical expertise, it takes around 10,000 hours of deliberate practice, with similar estimates for expertise in domains as diverse as chess, science, darts, and athletics. It is reasonable to expect that if anyone wants to develop high level skill and knowledge in any domain, it will take thousands of hours of hard work, and more likely tens of thousands of hours. Thus, one approach to understanding the development of cognitive sex differences is to ask how females and males spend their time.

One large between-sex difference is the amount of time spent playing video games. In a survey in the United States, researchers found that 36% of adolescents regularly played video games (Cummings & Vandewater, 2007). Of those who regularly played video games, 80% were male. Gamers (both male and female) spent 30% less time reading and 34% less time doing homework than nongamers. One recent survey found that boys in middle school play video games 266 more hours per year than girls do, for high school the annual difference is 305 hours, and for college the annual difference is 225 hours (Winn & Heeter, 2009). Massive multiplayer online games (MMOs) are time intensive. On average MMO players spend 22 hours a week playing their favorite game, and most of these players are male. Researchers determined that one reason, possibly the main reason, why males spend so many more hours playing video games than females do is that males have twice as much free

time as females (almost 9 hours a week compared to 4.5 hours a week for females). Across all age groups, females also have their free time in smaller “chunks” because they spend more time on obligatory tasks. Researchers link these differences to gender gaps in STEM fields, especially technology. When differences in how females and males spend their time are added up across a lifetime, they are staggering. If a man lives until the age of ninety he will have had 16,848 hours more free time than a woman in his adult life (that is 702 days or almost two more years of free time).

There are large differences in how males and females around the globe spend their time. For example, among children and young adults between 10 and 24 years old in rural Bangladesh, girls spend significantly more time working and less time studying (Amin & Chandrasekhar, 2009). Researchers calculated that over the school years, Bangladeshi girls spend 130 hours less time studying than boys do. Possible reasons for these differences in the lives of girls and boys in Bangladesh include social norms favoring sons, early marriage of girls, and higher returns on investments for boys who are educated. In a cross-national study of several “developing countries,” researchers (Ritchie, Lloyd, & Grant, 2004) concluded that although the lives of boys and girls are becoming more similar as the number of adolescents enrolled in school increases, female adolescent students still work longer hours than male adolescent students. Even among college students in the United States, whose lives seem like they should be a similar mix of attending class, doing homework, working, and engaging in leisure activities, there are large sex-related differences in how they spend their time. For example, Astin, Sax, Korn, and Mahoney (1995) found that female students spend much less time exercising, partying, and watching television, and much more time on housework, child care, reading for pleasure, and doing volunteer work than male students.

Differences in time use for males and females continue throughout the life span. In the United States, married mothers spend more time caring for children and ill and disabled family members than their spouses do (actual values vary with the age of the children and employment status of the spouse), and married fathers spend more time at work than their spouses do (Bureau of Labor Statistics, 2008). Despite all of the efforts of those associated with the “Women’s Movement,” *de facto* sex-related life differences are alive and well.

Implications of Psychosocial Explanations

By far the most prevalent crippling disease—for both boys and girls—is sex stereotyping.

—Dr. Benjamin Spock (pediatrician who is the author of very popular parent education books, quoted in Zimmerman, 2004, p. 74)

If we can use psychological and social explanations to understand cognitive sex differences, then the possibility of reducing or eliminating these

differences is quite real. On the other hand, if we find that we are unable to explain these differences with psychosocial explanations, then there is little hope of being able to alter them by changing learning environments, attitudes, or educational and employment opportunities. Thus, the primary importance of psychosocial hypotheses is not in their heuristic value or for the development of some abstract theoretical model, but in the promise they hold for changing the status quo. Of course, if you are a champion of the status quo, then they are equally important, but for you they would represent a threat to your preferred hypothesis. In either case, the implications are clear. Psychosocial hypotheses devised to explain the origin of cognitive sex differences have important ramifications for the ways we want society to change or remain the same.

Nonconscious Ideology

Perhaps one of the reasons for the tendency to underestimate sex-differentiated experiences, messages, and expectations is that these differences are so prevalent and so ingrained in American life that we are often blind to them. In fact, for most of us, it is hard to imagine a society in which they did not exist. Bem and Bem (1976) coined the term “nonconscious ideology” to describe this situation. We are simply unaware of the pervasiveness of sex-differentiated practices. They said that we are like fish that are unaware that the water is wet. The clothes we wear, the way we furnish our rooms, the toys we were given as children, the hobbies we pursue, the salaries we receive at our jobs, the magazines we read, the household chores we perform, the language we use, and countless other examples all show differences between the sexes.

There are innumerable examples of the way American and other western societies have nonconsciously adopted sex-differentiated practices. We expect to see little girls in the advertisements for Barbie dolls and little boys depicted on boxes that contain train sets and, therefore, never stop to consider the powerful messages they convey about sex-appropriate interests and behavior. For example, I remember receiving a prize for serving as president of my high school’s honor society. I was delighted with the bracelet I was given. I knew that all of the previous honor society presidents were male, and all of them had received a six-volume set of books by Winston Churchill. Yet, it had never occurred to me that the choice of this particular gift was an excellent example of sex-differentiated socialization practices. It was not until many years later that I was struck with the irony of the gift. Like most other people, I was simply unaware of the numerous subtle and not so subtle practices in our sex-differentiated society.

Later in life, when my own children were in school, I complained to the principal of our local elementary school when I learned that there would be two winners for a school fund raiser—the boy and the girl who sold the most raffle tickets. The boy’s prize was to be a walkie-talkie set, and the girl’s prize was to be a stuffed animal. The principal did not understand my concern. He assured

me that boys like walkie-talkies, and girls like stuffed animals. I suggested that if he wanted to name two winners, why not let them be the top two children who sold the most raffle tickets, regardless of their sex, and to allow each winner to select either a walkie-talkie or a stuffed animal. The principal could not see any merit in my suggestions, and the prizes were awarded as they had been announced. I do not believe that any single act, like this one, has much effect on the cognitive abilities of children, but they become part of a larger pattern of messages and outcomes that can have a powerful cumulative effect.

The Words We Use

“A local newspaper story with the title *Girl Talk* describes the final round of talks between English Prime Minister Thatcher and Indian Prime Minister Gandhi in New Delhi. A headline in another newspaper reads, ‘Barrister and Woman Found Dead’.”

—Philip M. Smith (1985, pp. 31–32)

Consider, for example, the simple matter of the grammatically correct use of the pronoun “he” to mean he or she (or she or he). Somewhere in junior or senior high school, we were all taught that the grammatically correct singular pronoun when sex is unknown is “he.” Thus, it is grammatically correct to say, “Everyone should do his homework.” There have been many objections to the use of “he” to mean “he or she.” The use of “he” to refer to either sex has become known as the “generic he” to signify that its use is much like the use of generic labels for supermarket canned goods. One argument against changing from the generic he to either “s/he” or novel terms (e.g., *te* or *E*) is that the issue is trivial and of no real significance. Detractors have humorously labeled this debate as a case of “pronoun envy,” a humorous take-off on Freud’s theory of penis envy as a major determinant of sex differences. Research has shown, however, that the issue is far from trivial. MacKay (1983) studied the use of the generic “he” to determine its psychological significance. He estimated that the generic “he” is used over 1,000,000 times throughout an individual’s lifetime. In addition, he found that people tend to think of a male whenever the pronoun “he” is used. It is clearly not a sex neutral or generic term from a psychological perspective.

The difficulty in solving the problem about what pronoun to use when talking about a person whose sex is unknown was discussed in the column “Grammar Girl,” where modern answers to grammatical problems are discussed and answered. Here is what Grammar Girl (2006, para. 3) has to say: “*He* or *she* seems too awkward, *he* seems sexist, and *one* seems archaic. I would add that exclusively using *she* also seems sexist, the hybrid *s/he* seems silly and awkward, and switching between *he* and *she* is downright confusing to readers.” Readers of this website devoted to grammar were asked to vote on the best way to fill in the blank for this sentence: “A patient who lies endangers

_____ health.” The results were 3% for “her,” 25% for “his,” for 40% “his or her,” and 32% for “their.” One suggested solution is to avoid this situation by using plural constructions (patients . . . their) or rewording the sentence.

I remember once reading about the hardships encountered by early American pioneers and their wives. The nonconscious implication is that the women were not pioneers in the same sense that the men were.

Consider this example of the subtle biasing effect that masculine pronouns can have:

Because students are most familiar with the ways of the college professor, many choose academic careers which can range from the research scientist involved with man’s search for knowledge to the psychologist trying to help solve his client’s problems. . . . The average corporate businessman probably earns at least twice the salary of the college prof, yet he probably has half the education.

(Example taken from a study of gender-biased language
by Murdock & Forsyth, 1985, p. 39)

Part of the nonconscious ideology of sex role stereotypes is an unstated assumption that the male is norm and departures from a male pattern of results are therefore deviant. If you still doubt that the English language conveys a strong male bias, try this: Ask several friends to provide the correct singular terms for (1) a married couple, (2) children, (3) siblings, (4) royalty, (5) the first humans named in the Bible, (6) people who give parties. See how many people give you these terms in the word order in which we expect to hear them—that is, the male term first: (1) husband and wife, (2) sons and daughters, (3) brother and sister, (4) king and queen, (5) Adam and Eve, (6) host and hostess (Smith, 1985). It must be more than coincidence that most people name the male title first. Similarly, men are addressed as “Mr.” throughout their adult lives, irrespective of their marital status; yet, women have traditionally been addressed in relation to the men they marry and carry either the title of “Miss” or “Mrs.” There are still many people who object to the use of the marriage-irrelevant title of “Ms.” for women. Smith (1985) noted that there are no feminine-oriented generics for terms like “bachelor’s degree,” “brotherhood,” “mankind,” “spokesman,” and “workmanlike.”

Androcentric Bias in Psychology

In a review of four major journals in psychology, spanning the time period between 1965 and 2004, researchers found that it was rare to use the pronoun “he” to refer to both females and males (only 7.7% of the articles; Hegarty & Buechel, 2006). The researchers also found that “Female and male psychologists writing across the decades in different journals all rendered men and boys the norm for comparison and rendered women and girls as the effect to be

explained, to much the same degree” (p. 382). They noticed that tables, graphs, and other visual displays position males first and females second (74% showed males first). The researchers discussed whether these results show important biases in which males are assumed to be normative or whether they merely show that there is a bias, which is relatively harmless. They concluded that norms are communicated by what goes unspoken, including the way data are displayed and how unintentional androcentrism (assuming that being male is central or normative) may contribute to perpetuating male privilege.

Causal Statements in Psychosocial Research on Stereotypes

Critics of research on psychosocial influences on sex differences in cognition are quick to point out that sex differences in language usage cannot be used to infer causality because these data are correlational in nature; that is, we cannot determine if children act in sex-differentiated ways because of the language we use, or if we use sex-differentiated language because children act in sex-differentiated ways. Similarly, we cannot conclude that the androcentric bias found in psychology research articles causes anyone to change how they think about females and males. I discussed the limitations of correlational research in [Chapter 2](#), and it is instructive to reconsider correlational research in this context. Although it can be more difficult to establish causality with social variables than with biological ones because we cannot assign people at random to different long-term social situations, it is not impossible. We can look to other societies as well as to variations within a particular society to illuminate the relationship between social variables and sex differences. For example, we could compare children who live in the same neighborhood and attend the same school, but differ in the way their families encourage or discourage sex-role stereotypic behaviors. As you read about the psychosocial research that has been conducted on cognitive sex differences, be sure to keep these criticisms in mind and be as tough a critic as you undoubtedly were for the biological hypotheses.

SEX ROLES AND SEX ROLE STEREOTYPES

Girls’ play involves dressing and grooming and acting out their future—going on a date, getting married—and boys’ play involves competition and conflict.

—Glenn Bozarth (spokesperson for Mattel Inc. quoted in *New Woman*, 1990)

There has been a shift over the last decade or so in our understanding of stereotypes. An older definition of stereotype is that it is “a relatively rigid and

oversimplified conception of a group of people in which all individuals in the group are labeled with the so-called group characteristics” (Wrightsmann, 1977, p. 672). More recently, definition of the term “stereotype” includes the idea that they are often fairly accurate—at the group level. Stereotypes contain our knowledge and expectancies about a group of people. Stereotypes include two types of beliefs—expectations about what members of some group actually are like and what they should be like (Eagly & Sczesny, 2009). As a society, we have stereotypes about racial groups (e.g., “Blacks are musical.”), nationalities (e.g., “The Scots are thrifty.”), sports groups (e.g., “Football players are dumb.”), people who wear eyeglasses, New Yorkers, redheads, obese people, cellists, Republicans, etc. Any of these stereotypes can influence interactions, feelings, and expectations. Sex role stereotypes relate to differences between the sexes. For the purposes of this discussion, the term “sex role stereotypes” will be used to encompass widely held assumptions about what females and males are like, as well as what they ought to be like. Two questions concerning sex role stereotypes that have been raised are: Is there any evidence that they exist, and if so, can these stereotypes be used to understand sex differences in cognitive abilities? Readers can probably guess that by the end of this chapter, my answer to both of these questions is “Yes.”

Repeatedly, the term “sex roles” has come under attack (Lopata & Thorne, 1978). Those opposed to the term have argued that since we do not use terms like “race roles” or “class roles,” why should researchers be so concerned with reifying (making a theoretical concept real or concrete by giving it a label) the concept of sex roles? It has also been argued that other roles in life, like that of student, or factory worker, or young adult, undergo changes as our life situations change, whereas sex roles do not change because they are tied to biological sex. It is also frequently argued that the term “gender roles” is more appropriate than “sex roles” because the term denotes societal rather than biological influences. Despite all of the rhetoric generated by the term “sex roles,” it is likely to remain in the psychological and sociological literature. One of the leading journals in the area of sex differences is entitled *Sex Roles*, and the term seems to have an intuitive meaning for people outside of academia.

It is a widely held belief that sex role stereotypes, those beliefs about behaviors and dispositions that characterize males and females in our society, exert strong influences on male and female behavior.

As Prentice and Carranza (2002, p. 269) reminded us, “Gender stereotypes are highly prescriptive.” They found that traits that were desirable for each sex were also believed to be typical of each sex. For example, it was desirable for men to be athletic and self-reliant, and they were also rated as being more athletic and self-reliant than women. A parallel example for women is that it is desirable for women to be warm and kind and more typical for women to be warm and kind. These researchers also found that there are differences in the extent to which positive and negative traits that are associated with one

sex are also permissible (they called this a “relaxed” prescription or proscription) or not permissible (they called this an “intensified” prescription and proscription). An example of each of these categories should help with this concept.

Intensified prescriptives (positive traits that are associated with one sex, and rarely found in the other sex):

Business sense is a positive trait for men that is rarely found in women.

Interest in children is a positive trait for women that is rarely found in men.

Relaxed prescriptives (positive traits that are associated with one sex, but also found in the other sex):

High self-esteem is a positive trait for men that is permissible for women.

Friendly is a positive trait for women that is permissible for men.

Intensified proscriptives (negative traits that are associated with one sex, and rarely found in the other sex):

Arrogant is a negative trait associated with men that is rarely found in women.

Melodramatic is a negative trait associated with women that is rarely found in men.

Relaxed proscriptives (negative traits that are associated with one sex, but also found in the other sex):

Controlling is a negative trait associated with men, but also found in women.

Yielding is a negative trait associated with women, but also found in men.

In general, there are more “intensified proscriptions” for men—more traits that they are not permitted to have. Stereotypes seem to be narrower or to allow fewer options for males, leaving boys and men fewer choices and dispositional alternatives. Generally, it is far more deviant for a male to engage in traditionally female activities (e.g., homemaker, nurse, or secretary) than it is for females to enter the traditional man’s world (medicine, physics, trucking, plumbing).

The impact of sex role stereotypes comes from pervasive life-long influences to conform to a pattern of behavior that is prescribed by sex. Sex differences in cognitive abilities mirror sex stereotypes about abilities, making it very difficult to determine the extent to which differences in abilities and stereotypes influence each other. The sex role literature is extensive. It contains numerous confirmations of the hypothesis that these stereotypes exert powerful influences on the way we think and behave. When it comes to leadership roles in business and politics, there is clear evidence that many people hold different

beliefs about women and men. People tend to assign the caregiver-family role to women and assertive-career role to men, keeping them aligned with traditional sex roles where men are the breadwinners and women are the bread bakers. A recent study found that these stereotypes persist—both men and women believe that male leaders “take charge” while female leaders “take care” (Catalyst, 2006). For example, when Hillary Clinton stumbled on a question during the U.S. presidential debates in 2008, the other candidates and critics rushed in to take the advantage. You are probably thinking, so what—this is what political candidates do. But in making her look ridiculous they “did Hillary imitations, complete with mincing steps and effete hand gestures,” as *New York Times* columnist Stanley Fish (2007) described the ensuing events. They ridiculed her by exaggerating female stereotypic behaviors and women’s generally higher pitched voice. Some readers will respond to this as “no news” because political candidates attack whatever they can about their opponents, but by emphasizing to the public extreme female traits, they were subtly reminding voters about negative female stereotypes and why they might not want a woman for president.

It is difficult to know how these beliefs affect voting patterns, but there is ample evidence that racial and religious stereotypes have affected the outcome of numerous political campaigns. Few would doubt that sex role stereotypes have kept qualified candidates from office.

If you doubt whether sex role stereotypes still exist, consider a few of the questions taken from a questionnaire that was designed to show that sex role socialization is alive and well in contemporary society (Jonides & Rozin, 1981):

- | | |
|--|----------------|
| Would you be willing to kill a cockroach by slapping it with your hands? | (a) yes (b) no |
| When you are depressed, does washing your hair make you feel better? | (a) yes (b) no |
| Do you walk around freely in the nude in a locker room? | (a) yes (b) no |
| Can you sew well enough to make clothes? | (a) yes (b) no |

Ask several male and female friends and see if you can detect a sex-related difference in the way your friends answer these questions. How does sex role socialization explain these differences?

Agency Versus Communion

Numerous past studies have reported sex differences in value priorities.

—Shalom H. Schwartz and Tammy Rubel (2005, p. 1010)

What are the stereotypes about women and men that exist in North America and other parts of the world today? This question has been researched extensively by psychologists, sociologists, and others during the last several decades. In the numerous studies that have been conducted, two distinct clusters of traits have

emerged. In general, (1) male stereotypic traits suggest competence and task orientation, a cluster of traits sometimes known as “instrumental” or “agentic,” which is derived from the word “agency,” meaning to take action, while (2) female stereotypic traits suggest warmth, communion (group oriented and caring about other people), and expressiveness (Bakan, 1966). It seems that these differences in the traits that people ascribe to women and men are correlated with sex-related differences in the traits that men and women value. In an international study using 127 samples from 70 countries (Schwartz & Rubel, 2005), men and women attributed importance to 10 different values. In 96% of the samples, men attributed greater importance to power and in 90% of the studies, women attributed greater importance to benevolence. Other between-sex differences were that men valued achievement more than women did, and women valued security more than men did. Although the terms differ slightly among studies, the general idea that women and men have different values holds up internationally, although the effect sizes tend to be small and vary across countries.

Sex differences in agency and communion can be found in children. For example, consider a survey of 508 children and young adults (ages ranged from 13 to 18) that was conducted in England (Miller & Hayward, 2006). Participants were presented with a list of jobs and asked, “Who should do this job: men, women, both?” and “Who mainly does this job: men, women, both?” (Astute readers will recognize that the term “men” was consistently listed first in the way the questions were asked, and probably will not be surprised to learn that the report of this research listed male responses before female responses. This journal article would have been classified as showing an androcentric bias by the researchers who studied how research data are presented.) The data shown in [Figure 6.1](#) depict the extent to which the respondents believe that the occupations listed *should be* performed by males or females. As readers can probably surmise, bars above the zero marking are stereotyped as appropriate for males and those below the zero marking are stereotyped as appropriate for females. With only one exception, the girls and boys agreed on which jobs are appropriate for each sex. The lone exception is “dentist,” but the differences for this occupation are so small they are not meaningful, with boys indicating that it is equally appropriate for both sexes and boys showing a slight preference for women as dentists. The only other occupations that were appropriate for women from the list the children and young adults were shown were hairdresser, nurse, occupational therapist, physiotherapist, secretary, and a slight preference for “maths teacher.”

Diekmann, Brown, Johnston, and Clark (2010) used the agency versus communion framework to explain why women opt out of STEM field careers. They provided undergraduates with a list of careers that are primarily occupied by either women (e.g., social worker, nurse, education administrator) or men (e.g., lawyer, architect, and physician). The students were asked to consider how well each career would fulfill agentic goals (power, achievement, excitement) or communal goals (intimacy, affiliation, altruism). They also had

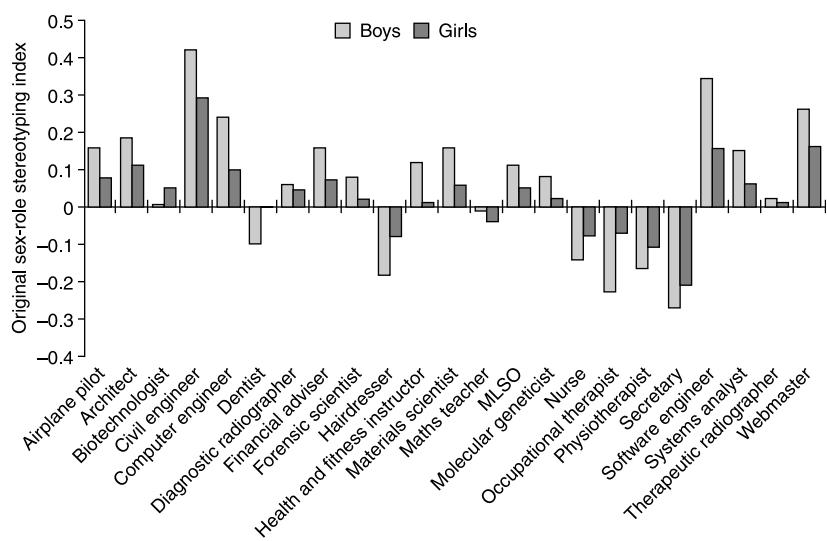


Figure 6.1 “Who should do this job: men, women, both?” Responses from 508 students ranging in age from 13 to 18 in the United Kingdom. Bars above the horizontal line indicate occupations that are more appropriate for males and bars below the horizontal line indicate occupations that are more appropriate for females. From Miller and Hayward (2006). Reprinted with permission of Taylor & Francis.

students indicate their interest in various careers and rate the extent to which they endorsed communal and agency goals. They found that when individuals endorse communal goals, which are most often endorsed by women, they are less interested in STEM careers. The researchers concluded that it is ironic that STEM fields hold the key to helping many people, but they are usually regarded as unrelated to communal goals.

Here is another example of the powerful influence of agency versus communion as a system of values. Letters of recommendation for faculty positions in higher education were examined to determine if women were more likely to be described with adjectives that connote communal terms (e.g., affectionate, warm, kind) and less likely to be described with agentic terms (e.g., assertive, confident, ambitious; Madera, Hebl, & Martin, 2009). As you might expect, they were. But the more critical finding was that communal characteristics have a negative relationship with hiring decisions in academia. Other research has shown that communality is not perceived to be as congruent as agency with managerial jobs or leadership (e.g., Eagly & Karau, 2002). Thus, it may be differences in how we perceive people along the dimensions of communality and agency that are influencing individual career decisions and hiring

decisions. Asking if it is better to exhibit warmth or competence is like asking if you prefer blue objects or triangles. There is no right answer, except for the possibility that both are desirable.

Interests, Values, and Attitudes: People Versus Things

It appears that group status (i.e., sex) is a frail proxy variable for specific individual differences.

—David S. Lubinski and Camilla Persson Benbow (2007, p. 88)

There are strong and consistent differences in the interests, values, and attitudes of females and males in contemporary western society. This conclusion is based on studies using the Allport–Vernon–Lindzey Scale of Values (1970) assessment instrument over many decades (Lubinski, Schmidt, & Benbow, 1996). The scale yields patterns of interests that are typical of either males or females. These differences in interest reflect the differences that are found in male-typical and female-typical vocational choices. Scales of this sort are frequently used in career counseling. Lippa (1998) examined sex differences along a personality dimension anchored at one end with “people”-oriented interests and at the other end with “thing”-oriented interests. Lippa (2001) later proposed that our concepts of masculinity and femininity overlap substantially with sex differences in the extent to which people are interested in people versus things. The “people–things” dimension is an index of the extent to which individuals prefer work that involves interpersonal tasks (teaching, taking care of, or directing others) or impersonal tasks (working with machines or tools). He found a strong relationship between sex and scores on this scale. With participants from three separate studies, females showed a strong preference for the “people” end of the dimension with males showing a strong preference for the “things” end of the dimension.

In a recent meta-analysis, researchers used the people–things dimension as a way of understanding why women are underrepresented in STEM fields (Su, Rounds, & Armstrong, 2009). They reviewed data from 47 interest inventories with 503,188 respondents. The researchers used a classification system that was proposed by Holland (1977) in which people are rated on six types of interests: It is called the RIASEC coding, with each letter denoting one dimension of the scale. Many vocational interest inventories, including the Strong Interest Inventory (Donnay, Thompson, Morris, & Schaubhut, 2005), have incorporated Holland’s theory for describing vocational interests. Here are the dimensions for RIASEC:

Realistic: Mechanical interests that include working with gadgets

Investigative: Interest in science and in solving problems, including conducting research

Artistic: Appreciation for the arts and creativity, including writing

Social: Preference for working with and helping people, often in teams

Enterprising: Power, leadership, and status preferences directed toward economics

Conventional: Preference for well-structured environments, organization, and accuracy

Researchers found sex differences on five of these dimensions. Look carefully at [Figure 6.2](#), which shows these six dimensions aligned around a circle with “things and people” at opposite poles along the vertical axis and “data and ideas” at opposite poles along the horizontal axis. Men were significantly more likely to indicate an interest in careers that are realistic ($d = 0.84$) and investigative ($d = 0.26$); women were significantly more likely to indicate their

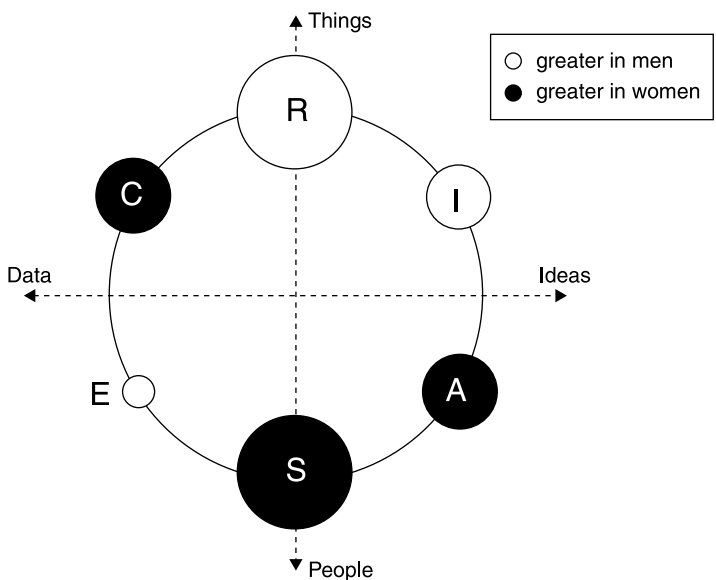


Figure 6.2 Sex differences on the six categories used to determine interest in different occupations. Note that the six categories are aligned along a circle, with “Things–People” forming the vertical axis and “Data–Ideas” forming the horizontal axis. In general, men are more interested in working with things and women are more interested in working with people. From Su, Rounds, and Armstrong (2009). Copyright © 2009 American Psychological Association. Reproduced with permission.

interest in careers that are artistic ($d = 0.35$), social ($d = 0.68$), and conventional ($d = 0.33$). Only enterprising failed to show significant sex differences. The differences between men and women were large, with almost a standard deviation in the things–people dimension. (I am guessing that I do not need to add that men were more interested in things and women were more interested in people.) Over a century ago, Thorndike (1911), the early American psychologist, wrote about a one standard deviation difference between girls and boys on this dimension, so although it has not been a popular idea, it has been around a long time. These results are reminiscent of the classic division proposed by British scientist C. P. Snow (1960), who wrote over 50 years ago about two cultures—the sciences and the humanities. Snow called for more meaningful connections between these two worlds and more interdisciplinary work that crosses these boundaries.

The reasoning behind vocational interest inventories is that it is necessary to go beyond cognitive abilities when thinking about the career and school-related choices that people make. We all have “trait complexes,” which are composite variables created from personality variables, interests, abilities, knowledge, cognitive abilities, and self-concepts (Ackerman, 2003; Kanfer, Wolf, Kantrowitz, & Ackerman, 2010). People seek situations that are consistent with their trait complex—both their abilities and their personalities and interests. When a battery of measures including both cognitive abilities (verbal, quantitative, and visuospatial) and personality variables was used, researchers found that these composite measures significantly predicted college grade point average, but only the non-ability trait measures predicted job performance. Thus, according to this view, we need to consider personality variables if we want to understand sex differences in job preferences and by extension, in the courses we take in school, the abilities we develop, and the way we spend our free time.

Lubinski, Benbow and their colleagues (see Lubinski & Benbow, 2007, for a review) have published several studies that support the idea that women and men have different interests that influence career choices. Most of their work is with academically precocious youth, many of whom were studied longitudinally from their preteen years into their 40s. These researchers argue that it is the difference in ability patterns (being better in either math or science) and interests that is most important in answering the question about why women are underrepresented in STEM fields. I expand on this distinction in the following chapter.

When considering complex social variables, such as preferences, interests, and values, it is difficult to determine what is causal. Regardless of the direction of the causal arrow, it is easy to see how greater liking will lead to higher motivation, more course work in a particular subject area, greater expectations for success, followed by increased knowledge and skill. The interwoven web of variables operates in ways that support beliefs about the differences between the sexes.

The Beauty Factor

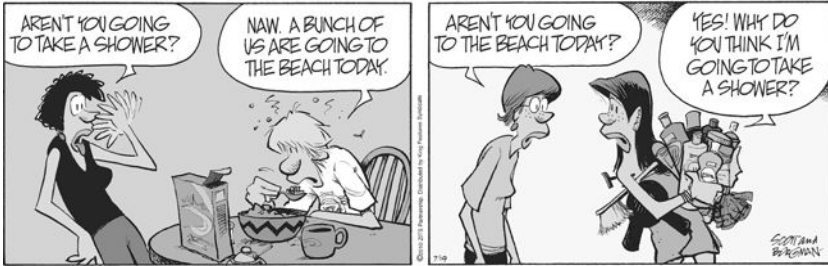
Being a little Barbie doll says your body has to be a certain way and your hair has to be a certain way. In girls particularly, this can unleash a whole complex of destructive self-experiences that can lead to eating disorders and all kinds of body distortions in terms of body image.

—William Pinsof, clinical psychologist and president of the Family Institute at Northwestern University, comments on child beauty pageants (undated)

Beauty pageants are one of the fastest growing industries in the United States (Nussbaum, undated). Girls learn about the importance of being beautiful at an early age. In the United States, children's beauty pageants attract an estimated 3 million children a year (Woodburn, 2010). Child beauty pageants are big business, with age of competition extending down to infants and toddlers. Young children model sportswear, evening attire (this is not a typo), and are judged on their looks, poise, "perfection," and confidence. As readers can probably guess, the overwhelming majority of participants are little girls. The message is clear—good looks matter for little girls.

Research on the advantages of being attractive finds that "beauty-is-good," which means that there are social advantages for attractive people, including higher ratings on sociability, altruism, and intelligence than their less attractive peers (Griffin & Langlois, 2006). In one study, researchers examined the nonverbal cues that convey the idea that beauty-is-good (Weisbuch & Ambady, 2009). There is a large literature showing that nonverbal inferences can be made in milliseconds, so even short snippets of a television show can convey a strong message about the value of being beautiful (e.g., Pessoa, Japee, Sturman, & Ungerleider, 2006). For example, slim characters on television are treated better by other television characters than their heavier counterparts, and these interactions are instructive to the audience. The authors of a study on this topic concluded that implicit biases are alive and well in western societies. Although men have higher self-esteem when it comes to physical appearance (Gentile, Grabe, Dolan-Pascoe, Twenge, Wells, & Maitino, 2009), the effects of the beauty bias have economic consequences, for both men and women, with an estimated 15% in pay difference between the most and least attractive (Hamermesh, 2011). Even when controlling for age and experience, men earn about 25% more than women, and many researchers believe that some portion of this difference is attributable to higher beauty standards for women (Andreoni & Petrie, 2008). Beauty and gender work together to affect the way people are treated by others.

Women, in general, do spend more time on their appearance, but the differences between men and women in this regard are less than most people might have guessed. *Allure* and *GQ* magazines (two popular fashion magazines in the United States, one geared toward women, the other toward men) conducted a study of time spent on "grooming" and number of grooming products used



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(Chernikoff, 2010). One thousand women and 1,000 men between the ages of 18 and 64 responded to a survey. The men spend an average of 22 minutes a day on their “beauty regime” compared with 29 minutes for women. Women in 2010 reported using 16 beauty products (e.g., shampoo, conditioner, mascara, foundation, deodorant, eye liner, blush, face powder, scented body wash, moisturizer, and more); men reported using 11 every day. The average of an additional 7 minutes per day by women adds up to almost an hour every week. It is also likely that the sample was biased for this study because it would attract men and women who are readers of fashion magazines. I would guess that the difference between women and men in time spent on grooming would be larger in a more representative sample, but I am careful to note that this comment is speculative, and some of men’s grooming tasks like shaving everyday are more time-consuming than most of the women’s tasks. Even if the data were an accurate reflection of the grooming of men and women, at 42.5 hours a year, women are spending about a working week more on grooming than men are.

Are Sex Role Stereotypes Changing?

By virtue of belonging to the social categories of men or women, individuals encounter broad expectations about men and women.

Amanda B. Diekman and Monica C. Schneider (2010, p. 488)

I have frequently been told by my students that “this sex role stereotype stuff is old hat.” Many people believe that sex roles have little relevance for today’s young adults. The data that provide an answer to the question of whether or not sex role stereotypes are changing provide a mixed picture. Like all complex questions, it seems that the answer depends on exactly what comparisons are being made and whether you view the results from the perspective of a “glass half empty or half full.”

Consider the percentage of respondents who agreed with the statement, “The activities of married women are best confined to home and family”

(reported in Myers, 1998, p. 566). In 1967, approximately 65% of men agreed, compared with approximately 30% in 1995. For women, approximately 45% agreed in 1967 and less than 20% agreed in 1995. Employment figures also show large changes in some areas such as the percentage of woman who work outside of the home and the number entering some formerly traditional men's fields like law and medicine. But, sex differences remain stable in other areas, such as secretarial work where over 90% are women and in engineering where approximately 80% are men. I have excluded from this list any reference to activities where body size is an advantage, like moving furniture, where more men might be expected because of their average larger size. Even in areas where physical size might be important, like moving furniture, women who are physically able to do the work are largely absent from that segment of the workforce. Similarly, women can vote in most, but not all, countries that hold popular elections, which is a major change over the last 100 years, but women still are rare among world leaders.

With a majority of women working outside the home in the last few decades, women have "increasingly endorsed stereotypically masculine instrumental/assertive traits" (Twenge, 2009). As the data on the increasing number of women entering traditionally male occupations such as veterinarian, medical doctor, lawyer, and accountant have shown, it is now acceptable for women to be instrumentally assertive. There are some data that show changing sex roles for men, most notably that they are spending more time with children than fathers did a generation ago (Families and Work Institute, 2006). To some extent, the traditionally female traits associated with being communal have become devalued, and more narcissistic traits such as the importance of being well off financially are endorsed by 75% of college students, up from 45% in 1967 (Astin, Oseguera, Sax, & Korn 2002).

Perhaps the best answer to the question about changing sex role stereotypes is that change over the last century has been slow and uneven. In 1946, Eleanor Roosevelt summed it up this way, "Against odds, women inch forward."



HOW STEREOTYPES DIRECT AND REFLECT REALITY

Gender typing must be viewed as multidimensional, encompassing such varied domains as activities and interests (toys, play activities, household roles, and tasks), personal-social attributes (personality characteristics and social behavior, such as aggression, dominance, dependence, and nurturance), social relationships (sex of playmates, friends), and stylistic and symbolic characteristics (gestures and nonverbal behavior, speech, and language patterns).

—Patricia J. Turner and Judith Gervai (1995, p. 759)

People are expected to behave in ways that are consistent with socially-defined sex roles (Eagly, Karau, & Makhijani, 1995). Sex role stereotypes provide the “shoulds” for much of our behaviors, and for this reason, have limited the possibilities for both men and women. Although much has been written about the deleterious effects of sex roles on women, they have been at least as damaging for men. Kimmel (undated) described how the male gender role has led to torture-like hazing in fraternities, dads who are uninvolved in their children’s lives, and violence. He cites the basic rules of being male: never do anything that even remotely hints at femininity; measure success by the size of your paycheck, wealth, and power; never show emotions; and be daring and aggressive. Kimmel, however, is optimistic that we can raise boys who are not fettered with these negative ideas about what it means to be male. In his book, *Guyland*, Kimmel (2008) describes the ugly and frightening place where young men grow up hampered by their sex role stereotypes, but he also offers alternatives to the sexism and homophobia that are part of the male sex role. Eagly and her colleagues have also found that, at least in the United States and Canada, the stereotypes about women often tend to be more positive than those for men (Eagly, Mladinic, & Otto, 1991), with positive and negative aspects associated with both sex roles.

I note here that concern about the negative parts of the female sex role is clearly justified in many countries in the world, where they are used to justify discrimination and domination. As I write this section, many girls in Afghanistan are not permitted an education, women are sold as slaves in Sudan, and female infanticide is a horrendous reality in many parts of the world. In Yemen, girls as young as 9 or 10 are married to men three times their age (Kristof, 2010). Discrimination based on sex can be seen in the literacy rates in many countries around the world. For example, 30% of women in Yemen can read compared to 70% of men. Perusal of the *World Factbook* for literacy rates shows that for every country in the world where the literacy rate is not universal (99%), women have lower rates than men do (Central Intelligence Agency, 2010a). Overt discrimination against females, including death, is a harsh reality in some parts of the world, a critical point that I return to in the final chapter.

Where did sex role stereotypes come from? Cross-cultural similarities suggest that they have a biological basis, but cross-cultural differences also

show that they have been molded to fit particular societal contexts. Most secretaries are women and most corporate executives are men. Secretarial jobs are consistent with sex role stereotypes about women's skills and abilities—supportive, neat, follows orders, low professional aspirations, and poorly paid; executive jobs are consistent with sex role stereotypes about men's skills and abilities—forceful, able to lead, aggressive, smart, and well paid. Differences in the status of some jobs in other parts of the world provide an interesting perspective on the interactive relationship between defining and reflecting reality. In Russia, for example, a physician is a low status job that does not pay well. Can you guess which sex constitutes the majority of physicians in Russia? If you guessed women, you win the prize. Thus, stereotypes both define and reflect reality.

Eagly and her colleagues have argued that sex role stereotypes come from the division of labor and that once a belief is formed, most people remain motivated to maintain that belief (Hart, Albarracin, Eagly, Brechan, Lindberg, & Merrill, 2009). The underlying idea is that when we look at the tasks that women and men perform, we assume that these behaviors reflect their internal characteristics. So, if we see women caring for babies, we tend to believe that women are caring and kind and if we see men in executive positions, we tend to believe that they are assertive and possess the skills of leadership. In other words, it is the occupational and social roles that are predominantly filled by men and women that lead to stereotypical beliefs about each sex. People assume “correspondence” between the behaviors they observe and the traits and attitudes of the people they are observing (Forsyth, 2004). Thus, one prediction for the future is that as women assume an increasingly diverse range of occupations, the stereotypes associated with being female will change as well.

A Network Model of Stereotypes

There is a popular riddle that goes something like this:

A young boy and his father went for a Sunday drive. A drunken driver swerved in front of their car, killing the father on impact. The young boy was rushed to the nearest hospital where the chief of neurosurgery was summoned to perform an operation. Upon seeing the boy, the chief of neurosurgery cried out, “I can’t operate on him, he’s my son!” How is this possible?

When I have posed this riddle to students, they have sometimes replied: “The chief of neurosurgery is the boy’s stepfather” “The real father didn’t die” or “It’s impossible.” Have you guessed the correct answer? The answer is that the chief of neurosurgery is the boy’s mother. The reason for the difficulty is that in our society, when we hear terms like “chief of neurosurgery” we tend to consider only males. The words we use can determine the kinds of thoughts we

think. Of course, if I had asked if a woman can be a neurosurgeon, everyone would have responded, “of course.” But when asked to think about a neurosurgeon, the idea that the person could be a woman does not come to mind. Try this riddle with some friends and family. I continue to be amazed by how many people cannot solve it.

What does this riddle tell us about how we think? When cognitive psychologists explain concept formation, they use an information processing model in which concepts are conceptualized as being interconnected in a web-like manner. As a way of understanding the network-like nature of stereotypes, take two minutes and write down the words that come to mind when you hear the word “woman” (or if you prefer, the word “man”). You may be surprised at your own thoughts.

Stop now and take two minutes to try this mini-experiment.

Are you back? Look over your list of words. How many of the following words were on your list: man, girl, boy, pink, baby, mother, father, home, work, cook, clean, husband, children, clothes, make-up, hair?

The words that are on your list represent the concepts that you associate with the concept “woman.” A cognitive model of stereotypes is based on the idea that we store and represent information in memory as meaningful concepts in long-term memory. Cognitive psychologists describe the process of thinking about something as activating a concept—bringing it to consciousness. They conceptualize memory as made up of concepts that are associated with each other. Some concepts are closely associated so that if one concept is “activated” (made conscious), closely related concepts are partially activated. Whenever any concept, such as “woman” is activated in memory, there is some activation that spreads to related terms. So if I showed you the following list of words one at a time on a computer screen: pink, baby, and mother, you would then be faster at recognizing the word “woman” if it were flashed quickly on the computer screen than if I had shown you words that are not related to “woman” such as desk, clouds, and dog.

Most people will think of the word “man” when asked to think about words that are associated with “woman,” so for most people these are close associates and whenever you think of “man” some of the “activation” of that concept in memory will spread to the concept “woman.” “Pink” is more likely to be a weak associate for “woman,” so if you think about the concept “pink,” only a small amount of activation will spread to “woman.” The connections among concepts in memory have different “weights” (Tang, Li, & Yan, 2010). According to this model, a concept is retrieved from memory when the sum of the various weights exceeds a threshold value. For this reason, it is called a computational model of memory. The idea that activating one node increases the likelihood that associated nodes become active is a central principle of network models of memory.

Another example should help clarify this model. Suppose I ask you to think about a hero. What “comes to mind?” You may be thinking about a heroic

rodent like Mighty Mouse, or Superman, or firefighters, or someone in the military. Of course, if you have never heard of Mighty Mouse (a cartoon character), then he will not come to mind when you think about a hero. Personal experience and culture will influence what you think about. Researchers found that when people are asked to name heroes, they name more male public heroes than female heroes (Rankin & Eagly, 2008). But, when people were asked to name heroes whom they personally know, women and men were listed equally. Just as we know that women *can be* neurosurgeons or heroes, men are more likely to come to mind when asked to think about these concepts because they are more consistent with the male sex role.

A social knowledge structure with links and nodes is shown in [Figure 6.3](#). The nodes are the concepts that we have stored in memory. Concepts are linked to other concepts that are associates. Look carefully at this figure that came from an article on implicit social cognition (Greenwald, Banaji, Rudman, Farnham, Nosek, & Mellot, 2002). “Me” is at the center of this network of connected concepts. The “Me” in this network is an intelligent, professor, grandmother, who is short and athletic. Other concepts are connected to these terms. For example, notice how “old person” is connected to “grandmother” and “forgetful” and “weak” are connected to “old person.” The concepts aligned on the left are associated with being female; those on the right are associated with being male. Concepts that are connected to “+” signs are positive, and those connected to “–” signs are negative. As explained in the legend for this figure, “stereotypes are associations of group concepts such as old person, grandmother, professor, male and female.”

There are many ways that stereotypes can become activated. For example, if you are at a meeting with a group of mothers who do not work outside the home, traditional stereotypes are more likely to be activated than if you are at a meeting with a group of women who are being recognized for their work as outstanding corporate executives. Of course, some of the outstanding executives are likely to also be mothers, but that is not the stereotype that would be activated in the executive setting. Thus, whether and when a stereotype is activated will depend on the strength (and number) of concepts that are associated with it and contextual variations.

Implicit Association Test

What would you do if the test exposed prejudices you didn’t even know you had?

—Oprah Winfrey (television talk show host, discussing the Implicit Association Test; *The Oprah Winfrey Show*, 2007)

Although most people believe that they harbor few, if any, prejudices, readers may find it interesting, maybe even disconcerting, to take an online assessment known as the Implicit Association Test (IAT; Greenwald, Nosek, & Banaji, 2003). It offers a way to peek inside the mind and see what someone is thinking.

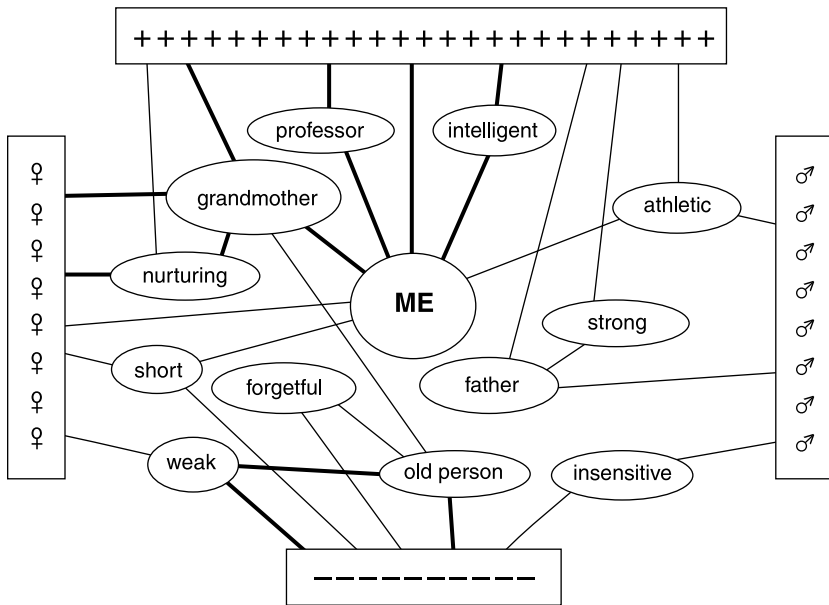


Figure 6.3 A social knowledge structure. This structure includes associations that correspond to social psychological constructs of self-concept, self-esteem, stereotype, and attitude in the psyche of an elderly female academic. Nodes (ovals) represent concepts and links (lines) represent associations. Line thickness represents strength of association. The *self-concept* includes links of the ME node to concepts that include roles (professor, grandmother) and trait attributes (intelligent, athletic); *self-esteem* is the collection of associations—either direct or mediated through the components of self-concept—of the ME node to valence (+ + + or - - -); *stereotypes* are associations of group concepts such as old person, grandmother, professor, male (♂ ♂ ♂), and female (♀ ♀ ♀) with attribute concepts; and *attitude* is the collection of links, either direct or mediated via components of a stereotype, that connect a social concept to valence. From Greenwald, Banaji, Rudman, Farnham, Nosek, and Mellot (2002). Copyright © 2002 American Psychological Association. Reproduced with permission.

It is a measure of the strength of automatic associations between concepts. The IAT measures how long it takes people to categorize terms. You can try it online at <https://implicit.harvard.edu/implicit/demo/>. There are several tests available, but for the purpose of this discussion, try the one on gender and science. In this test, participants are asked to make quick decisions about words associated with being male or female (e.g., George, Mary, Sally, Harry), then about words that are associated with the sciences and liberal arts (e.g., biology,

literature, novels, chemistry). These first two “tests” are easy. Then participants are asked to classify words under two different sets of instructions. First, classify a word into one category if the word pertains to either female or science and into a second category if the word pertains to either male or liberal arts. So, if the word “Sally” is shown, it would be classified into the category of things that are either female or science, and if the word “chemistry” was shown it would be classified into the same category. If the words “literature” or “Bob” appeared on the computer screen, these would be classified into the category of words that are either male or liberal arts. It takes longer to classify words under these instructions than it does when participants are asked to classify words if they are either female or liberal arts and male or science. The underlying idea is that being female and science and being male and liberal arts are incompatible concepts, and it will take longer to make these judgments than when the categories are compatible. The IAT measures the relative strength of associations between concepts, such as associating being female with liberal arts and being male with science.

Scores on the IAT are generally related to explicit measures of stereotyping (e.g., Can fathers be as good at parenting as mothers?), but the relationship is weak ($r = .24$; Hofmann, Gawronski, Gschwendner, Le, & Schmitt, 2005). Thus, it seems that people are not likely to say that they think in stereotyped ways, but their responses to items on the IAT show that most of us maintain stereotyped ways of thinking, even if we are not consciously aware of them. In fact, many people are surprised by their IAT scores, indicating that it is tapping cognitive processes that are not conscious (Lane, Banaji, Nosek, & Greenwald, 2007).

You may be thinking that none of this discussion about the power of stereotypes is relevant for you because you do not believe in stereotypes. You tend to see each person as an individual and do not have expectations based on an individual’s sex or other group membership (e.g., race, religion, type of employment, accent, etc.). Well, guess what? You are wrong! There is good evidence that categorization is an essential component in information processing, and we all use group membership categories when we interact with people. We may have different stereotypes and other beliefs, but stereotypes are fundamental to the thought process. Furthermore, they operate without our conscious awareness; they operate automatically (we can’t stop them), and sometimes we can’t articulate the categories that we are using (they operate implicitly).

The Threat is Real: Automatic Activation of Sex Role Stereotypes

There is convincing evidence that categorization of the basis of sex and race (and the activation of associated stereotypes in those categories) occurs prior to conscious awareness, involving information processing and

interpretation that are not subject to conscious, controlled, judgment and decision making.

—Human Capital Initiative Coordinating Committee (1998, p. 15)

Our understanding of cognitive sex differences has been greatly influenced by research that examines the effect of activating a stereotype just prior to or during test sessions where stereotypes are relevant. Steele and his colleagues (1997, 1998; Steele & Aronson, 1995) found that when talented students take an advanced test of mathematics with the usual expectations that men will perform better than women, the usual sex differences in average scores are found—men score higher than women. When talented students take the same test, but are led to believe that there will be no overall sex difference in test scores, then, in fact, the usual sex difference is reduced to little or none. This surprising result has been replicated many times using different groups and different sorts of stereotypes about the performance of each group. In fact, studies using this basic paradigm have become almost a cottage industry with several hundred studies conducted since 1995, when the original studies were published. Steele calls the depressed performance of stereotyped groups “stereotype threat.”

Steele’s explanation of stereotype threat begins with the idea that everyone has a “social identity”—our sense of who we are and what groups we belong to such as age, sex, race, profession, religion, socioeconomic status, and many more. Other people treat us in ways that are based on our social identity, and thus we remain vigilant for cues in the environment about the relevance of the groups to which we belong. For example, Steele told about his visit to a thriving computer-related company that was run by ambitious and super-smart young men and women. Everyone was dressed in jeans, there were posters of current rock groups he had never heard of pasted on the walls, and bicycles littered the hallways. There were multiple nonverbal cues that this was a place for young, hip people, which made his age salient and brought to mind stereotypes about old people. In other words, age was salient in the environment, so it brought about Steele’s own thoughts and feelings about being older than those who worked in this company. The young people who ran the organization were unaware that they had created an environment that was threatening to older people, and probably would have denied it, which is a classic component of stereotype threat—the target and observer have different assessments of threat to the identity of the target.

According to Steele, the following conditions must apply for “stereotype threat” to operate in a way that depresses performance for members of groups with negative stereotypes:

- 1 Everyone belongs to some group that has a negative stereotype (e.g., Italians, lawyers, old people, the unemployed, Latinos, Catholics, Arabs, cab drivers, the rich, the poor, people from Minnesota, people who wear glasses, golfers,

etc.). In order for stereotype threat to affect performance, the negative stereotype about your group must be relevant to the situation. Thus, if an advanced test of mathematics is given, the negative stereotype that women are not good at mathematics would apply, if you are a woman. If you are of Scottish descent, the negative stereotype that the Scots are “thrifty” would not be activated in this situation and would not affect performance.

- 2 The negative stereotype has to be one that the individual cares about. For example, if you are a woman who is planning a career as a singer, then the negative stereotype that women cannot “do” math will not affect performance on an advanced math test because you would not care about the score you achieved on that test. A stereotype cannot be threatening if you do not care about the outcome.
- 3 The individual does not have to believe that the stereotype is true. You could honestly believe that women are better than men in math, but if you are aware that most people believe in the stereotype that men are better than women in advanced mathematics, then it is activated. Common stereotypes are part of our shared culture.
- 4 The activation of a relevant and personally important negative stereotype disrupts performance, and it is this disruption that reduces the scores of group members when they are working on difficult problems. Stereotype threat would not be expected to affect performance on a simple test of mathematics, but when the material is difficult, its effects are found.

Steele provided powerful demonstrations of the way negative group stereotypes can depress performance on difficult and important tasks. In an interesting study of Asian women, two different stereotypes were pitted against each other (Shih, Pittinsky, & Ambady, 1999). In one condition, the stereotype that Asians excel at mathematics was made salient by first asking questions that would make the subjects aware of their Asian heritage (e.g., Do your parents speak languages other than English?). In another condition, the subjects’ sex was made salient (e.g., What are some advantages to living in a single-sex dorm?). Relative to a control condition that did not make either of these stereotypes salient, the Asian women answered more questions correctly in the Asian-salient condition than the control and fewer in the sex-salient condition than the control.

Can Stereotype Threat Explain Cognitive Sex Differences?

In high stakes standardized testing, men rule.

—Kelly Danaher and Christian S. Crandall (2008)

The competition for admission to selective colleges and universities is ferocious. Top-ranked institutions have many times the number of highly qualified

applicants as they can admit. As explained in [Chapter 3](#), men score higher on most standardized tests, including those used for college admissions, yet, on average females get higher grades in high school and college. Can stereotype threat explain the lower scores of women and non-Asian racial minorities on standardized tests? There is a huge research literature on stereotype threat conducted in laboratories around the world showing that it can depress the scores of stereotyped groups, but what about real-world tests? Is there evidence that stereotype threat actually operates to lower scores on high stakes tests? Stricker and Ward (2004) answered this question. They based their study on two premises related to stereotype threat: (a) the frustration that women have when solving difficult test items confirms the negative stereotype about women and math; and (b) it is the disruption produced by stereotype threat that interferes with the complex performance needed to solve difficult math problems. They tested these premises using two standardized tests, the Advanced Placement Calculus AB Examination and the Computerized Placement Test. Students took these tests under one of two conditions. In the threat condition, students were asked to indicate if they were female or male before taking the test, thus making sex salient before the test. In the nonthreat condition, students were asked to indicate their sex after taking the test, thus being male or female was not salient during the test for students in this condition. The researchers concluded that there was no effect of these manipulations on test scores. The data showed statistical significance, with girls scoring higher in the nonthreat condition, but the effect size was too small to be meaningful. That, however, was not the end of this story.

Danaher and Crandall (2008) reanalyzed the data presented by Stricker and Ward and calculated that given the large number of students who take these tests, even small effect sizes have large real-world effects. They calculated that 5.9% additional females and 4.7% fewer males would achieve a passing score of 3 or higher if sex and race were indicated after students take the test instead of before. The result would be 2,789 more females starting college with credit already achieved for calculus. Thus, stereotype threat has been found to have significant consequences on high stakes tests, even though the effect size is small. If you are keeping score, the initial score was 1 against stereotype threat. With the publication and reanalysis of the data by Danaher and Crandall, the score then went to 1 for stereotype threat. But the match was not over.

In a rejoinder to Danaher and Crandall's response, Stricker and Ward (2008) showed that Danaher and Crandall made erroneous assumptions when they reanalyzed the Stricker and Ward data. They rejected the claim that several thousand more women would pass the AP Calculus test if they did not have to indicate their sex until the exam is completed. In addition, Stricker and Ward note logical inconsistencies in the reanalysis of their data by Danaher and Crandall. (Stereotype threat cannot be used to explain the slightly lower scores women get on the verbal tests because there is no negative

stereotype about women's verbal abilities.) Data wars like this one are not unusual in science, especially when the stakes are high. This is an important exchange between these two groups of researchers because the Stricker and Ward study is one of only a few that used standardized tests in "operational use." In other words, they studied stereotype threat using real tests that count for something important. Stricker and Ward also emphasized that of the handful of studies of stereotype threat with operational tests, only one obtained results indicating that stereotype threat was influencing the outcomes.

Many other researchers have argued that stereotype threat is an important variable that depresses test scores. With several hundred studies on stereotype threat, I turn to two meta-analyses that were conducted to provide a meaningful conclusion that is based on multiple different studies. In one of the meta-analyses, researchers combined the results from 39 independent samples, which included 3,180 participants from nine countries (Walton & Spencer, 2009). They conclude that there are "psychological threats in common academic environments, which depress the performances of people targeted by negative intellectual stereotypes. Like the time of a track star running into a stiff headwind, such performances underestimate the true ability of stereotyped students" (p. 1132). They estimated that the SAT Math test underestimates the math ability of women by 19 to 21 points. Thus, even if their calculations are accurate, stereotype threat would not eliminate the difference in scores between men and women; it would, however, substantially reduce the size of the between-sex difference.

The second meta-analysis examined how scores changed under different types of threat conditions (Nguyen & Ryan, 2008). These researchers concluded that for women, subtle threat cues were more effective in suppressing scores on standardized math tests than more blatant cues. You can think of asking someone to indicate their sex at the start of an exam as a subtle cue for threat (a subtle reminder that you are male or female), whereas telling test-takers that men do much better on some test as they are about to take the test would be a blatant cue. They also found that the women who were moderately identified with math had the largest response to stereotype threat. It may be that women who do not identify with math are not threatened when they learn that men perform better (why should they care?), and women who are highly identified with math are so confident in their math abilities that manipulation of threat cues has no effect on their math test scores. The researchers who conducted the second meta-analysis calculated the size of the stereotype threat effect. They concluded that under standard threat conditions, the mean score for women is equal to the 34th percentile for men, but when threat is removed, the mean score for women is equal to the 41st percentile for men. Thus, both meta-analyses concluded that the between-sex difference in scores on high stake math tests can be reduced, but not eliminated, by altering threat cues.

Working Memory Capacity Moderates Stereotype Threat

How does stereotype threat influence performance? One theory designed to explain how stereotype threat affects performance is based on the capacity of an individual's working memory (Rydell, McConnell, & Beilock, 2009). Consider this possibility: Suppose you are majoring in engineering in college and you are about to take a test of logical reasoning, which you believe is a very important skill for engineers. You also recall that men often perform better on tests of logical reasoning. If you are a male engineering student, this situation should not produce stereotype threat because there are no negative stereotypes about the performance of the group to which you belong, but the reverse would be true for female engineering students. You then begin a timed test of logical reasoning that is fairly difficult. According to the working memory capacity hypothesis, the women are doing two cognitive tasks at the same time—they are working hard at solving the problems, while also processing thoughts about the negative stereotype they do not want to confirm. Thus, the women have a greater burden on their working memory.

If this hypothesis were correct, then those women with a greater working memory capacity, which means that they can perform multiple tasks at the same time without “overwhelming” their working memory, will be less affected by the negative stereotype than those women with less working memory capacity. Recent research found exactly these results, suggesting that the locus of the stereotype threat effect is working memory (Régner, Smeding, Gimmig, Thinus-Blanc, Monteil, & Huguet, 2010).

The Implicit, Automatic, Unconscious Nature of Stereotypes

In real life, stereotypes aren't triggered by lists of words but by skin color, gender characteristics, and other easily detected features of group members—in other words, by the actual presence of the person being stereotyped.

—John A. Bargh and Tanya L. Chartrand (1999, pp. 466–467)

One of psychology's major themes is that people are often unaware of the multiple influences on how they think, feel, and act (Gazzaniga, Heatherton, & Halpern, 2009). No one has any direct knowledge of the unconscious influences that affect them. Stereotypes often operate in ways that elude our awareness. Bargh and Williams (2006) refer to unconscious influences as the “automaticity of everyday life.” In a classic study, Bargh and his colleagues (Bargh, Chen, & Burrows, 1996) activated the stereotypes that college students have about elderly people. Students were told that they were participating in a test of language proficiency. They were given a list of words and had to make a sentence out of them.

Some of the students had words that were related to stereotypes about the elderly (e.g., Florida, old, lonely, gray, bingo, wrinkled, retired). Other students were given lists of words about a variety of different subjects (e.g., thirsty, clean, private). After this task was completed, the experimenter timed how long it took the students to walk down a corridor to the elevator. Students who had seen the list of words about the elderly walked significantly slower than those who had seen the control list of words. None of the students believed that the list of words might have affected them in any way. Their stereotypes about the elderly were activated without their conscious knowledge and affected their behavior (in this case how fast they walked). It is easy to imagine the multiple ways in which sex role stereotypes are activated and how these stereotypes can influence a wide range of behaviors, without any conscious awareness.

The Question of Accuracy

Understanding stereotype accuracy and inaccuracy is much more interesting and complicated than simpleminded accusations of racism or sexism would seem to imply.

—Jussim, McCauley, and Lee (1995, p. 3)

If, as assumed here, stereotypes both define and reflect reality, then it would be expected that stereotypical beliefs about what is true about men and women have, at least, a “kernel of truth.” In fact, recent studies of the accuracy of common stereotypes show them to be surprisingly accurate. In Eagly’s (1995, p. 145) review of the literature, she concluded that “On the whole, people do not exaggerate sex differences.” Most people realize that the sexes show considerable overlap on most traits and skills and reflect the degree of overlap in their stereotypes (Swim, 1994). Furthermore, most people take the context into account when they make their judgments about men and women, showing considerable sensitivity to the situational dependency of behavior. For example, in a large study of teachers’ beliefs about their students in sixth grade math classes (942 girls and 847 boys), the teachers reported that the girls were performing slightly better in math than the boys were, but that the two sexes were equal in mathematical talent (Jussim & Eccles, 1995). In fact, the girls did have slightly better grades than the boys in their fifth grade math classes and there were no sex differences in their scores on standardized math tests. The researchers reported that the teachers did not evidence any bias against girls and that they were very accurate in their assessments. (The teachers said that the girls were achieving higher than the boys despite having equal talent because the girls were trying harder, an idea that I expand on in the next chapter.)

One reason why understanding the stereotypes that people have and how well they match actual sex differences is important is that the entire theory of stereotype threat is predicated on the belief that most people share the same stereotypes about females and males and that these stereotypes are inaccurate

exaggerations of real group differences (see Jussim, Cain, Crawford, Harber, & Cohen, 2009, for a review). Many researchers have opined that the very notion of group “categorization exaggerates between-group differences and minimizes within-group differences, increasing perceived homogeneity” (Fiske, 1998, p. 375). In a recent study of group-based stereotypes (e.g., females and males), two students and I asked over 100 adults what they believed to be true about 24 possible sex differences in different areas of cognition (Halpern, Straight, & Stephenson, 2011). For example, one item read “Children learn to count in their preschool years. At what age do most girls (boys) learn to count to 10?” There are no data that support the notion that there are sex differences in learning to count. Another question asked, “What percentage of girls and boys are diagnosed with reading disorders?” To test the hypothesis that people tend to exaggerate cognitive sex differences, we compared the respondents’ beliefs with published data about actual differences. We found that across the 24 items, participants were generally accurate about whether males or females scored higher on different cognitive measures, but they also showed a tendency to underestimate the size of the differences between males and females. These results corroborate the findings of other researchers who have found group-based stereotypes to be either accurate or underestimates of actual differences in both the U.S. and Canada (e.g., Ashton & Esses, 1999; Cejka & Eagly, 1999; Jussim, Harber, Crawford, Cain & Cohen, 2005).

The results from studies of stereotype accuracy challenge the assumption that stereotypes are exaggerations of real group differences. Research on stereotype threat has grown exponentially in recent years with large numbers of studies showing how beliefs about the ways in which males and females differ can affect cognitive performance (Nguyen & Ryan, 2008). But without understanding what most people believe about the ways females and males differ, the research paradigm is missing a fundamental component. For example, do beliefs about the size of the sex difference predict the size of a stereotype threat? More specifically, will women who believe that there are large differences in the mathematical abilities of women and men show a greater reduction in their own performance on a high stakes test of advanced mathematics when their sex is made salient than women who believe that the difference is small or nonexistent? The empirical literature on cognitive sex differences is also growing at a rapid rate, but it may be as important to know what people believe to be true as it is to know about the ways females and males differ and are similar.

The finding that most people have fairly accurate perceptions about sex differences was surprising and upsetting to those psychologists who believed that common stereotypes ascribe greater dissimilarity to females and males than actually exists. This remains a “hot” area of contention among some researchers because it “runs against the theoretical Zeitgeist” (Lee, Jussim, & McCauley, 1995, p. xiii).

As a reader, you may be thinking that if stereotypes are often accurate and often unrelated to prejudice, then why should psychologists be concerned about them. In an online discussion of this question, the social psychologist Alice Eagly answered this question in a particularly thoughtful way. As Eagly reasoned, stereotypes are inaccurate in a very important way—they are not accurate for the large number of individuals who do not fit the stereotype, which is true of large numbers of people.

There exist basically accurate stereotypes about women, men, and leaders. Those stereotypes, by which leaders have mainly masculine attributes, create barriers for women who wish to occupy leader roles and exert authority in organizations and society. In general, the women who wish to take these roles are not stereotypically feminine, but possess the qualities of energetic assertiveness that qualify them for leader roles. (They may even be better than average men in their more androgynous, “progressive” leader styles.) But stereotypes about women and leaders make it difficult for their qualities to be correctly perceived or appreciated and instead often create a “double standard” that these women have to overcome to qualify.

(Alice Eagly, personal communication)

Thus, there are at least two problems with stereotypes, even if they are largely accurate about groups of people. They are always inaccurate for the large numbers of people who do not conform to the stereotype, and they make it difficult for individuals who are attempting to achieve outcomes that are not part of the stereotype. Thus, the message about stereotypes consists of two parts—they are accurate on average, but create barriers and are generally inaccurate for individuals who want to break away from their group stereotype.

REDUCING (MAYBE EVEN ELIMINATING) SEX ROLE STEREOTYPES

Gender is one of the most—if not the most—biologically primitive and important social categories. This would explain why it is the first social category that humans are able to discriminate (as early as 9 months of age), and consequently, why gender-related stereotypes are among the first stereotypes that humans develop.

—Alison P. Lenton, Martin Bruder, and Constantine Sedikides (2009, p. 183)

If gender is socially constructed, then how are these messages taught and learned by society members? A common theme among the theories of sex role acquisition is that these messages are conveyed in multiple ways, with positive feedback loops increasing the strength of the message. But, what can be done to reduce the strength of a stereotype? Again, given the sheer

size of the research literature on this question, I turn to a meta-analytic review for an answer that is based on many studies. Researchers examined 13 different studies containing 21 independent measures of stereotype reduction. There are many types of interventions designed to inhibit the automatic activation of a stereotype. As described in Lenton et al. (2009), these include: (a) inhibiting the activation of the stereotype, perhaps by asking participants to focus on a white dot when they view stereotypic materials such as a photo of a boy playing football; (b) activating stereotype-inconsistent representations, perhaps by instructing participants to image a strong woman or female math professor before taking a standardized test of mathematics; and (c) preventing the expression of the stereotype, perhaps by teaching participants to say “No” when they view the words “male” and “engineering” together. These three types of intervention methods are depicted in Figure 6.4. The general conclusion from this meta-analysis is that overall there are small, but significant reductions in automatic gender stereotyping with these interventions.

One strong result with a minimal intervention increased the average grades of women enrolled in a college-level physics course from C to B, with the greatest change for women who tended to endorse the stereotype that men do better in physics than women do (Miyake, Kost-Smith, Finkelstein, Pollock, Cohen, & Ito, 2010). This large change resulted from a simple intervention. Students in the “treatment” condition wrote about their most important values during two separate sessions at the beginning of a semester-long physics course. The researchers believed that writing about what is personally

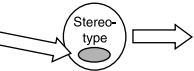
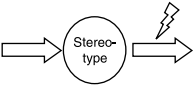
Intervention category	Process	Example
A 	Inhibit stereotype activation	Asking participants to focus on a white dot while they encounter stereotype-relevant material and before they complete an implicit measure of stereotypes.
B 	Emphasize stereotype heterogeneity by activating stereotype-inconsistent aspects of the category representation	Instructing participants to imagine a strong woman exemplar before completing a measure of implicit stereotypes.
C 	Prevent stereotype expression	Teaching participants to say “no” when encountering stereotypic stimulus combinations before measuring their implicit gender stereotypes.

Figure 6.4 Characteristics and examples of intervention methods. From Lenton, Bruder, and Sedikides (2009). Copyright © Blackwell Publishing. Reprinted with permission of Wiley-Blackwell.

important, such as family and friends, provides them with feelings of integrity and worth that can improve performance for students who believe that a group they belong to (in this case being female) does not achieve in a particular academic domain. The large effect for women who believed that physics is a male domain suggests that it reduced the threat of confirming that stereotype and improved exam grades. These studies suggest that the negative effects of stereotype threat can be overcome fairly easily.

Making Gender Salient

Schools should make it as unacceptable to use gender-specific language and divisions (e.g., “Good morning boys and girls”) as it is to use race-specific language and divisions (e.g., “Good morning black children and white children”).

—Lacey J. Hilliard and Lynn S. Liben (2010)

The general conclusion from the massive literature on stereotype threat is that it operates to depress performance on sex-stereotyped tasks when being female or male is made salient. What happens when gender is repeatedly made salient over several weeks? Do sex role stereotypes increase? To answer this question, Hilliard and Liben (2010) designed two different types of preschool classrooms. In one type of classroom, gender was made salient. In these classrooms, teachers were encouraged to make gender salient by physically separating the children by sex (e.g., lining children up by sex), organizing the classroom in sex-differentiated ways (e.g., posting separate boys’ and girls’ bulletin boards), and repeatedly using gender-specific language (e.g., “I need a girl to pass out the markers” and “Good morning boys and girls”). The other classrooms were low-salience—teachers avoided using gendered language or organizing space or activities based on sex. These researchers took numerous measures of stereotyping before and after this intervention. Children’s endorsement of gender stereotypes was assessed using an instrument that is appropriate for preschool children. The children were asked about their feelings about playing with children who were either the same sex as they are or the other sex and the children were observed at play. The results were striking. After only two weeks of being in a classroom where gender was made salient, the children in these classes, relative to children in classes where gender was less salient, showed decreases in gender flexibility (they saw the roles of girls and boys as more rigid); they were less likely to want to play with a classmate whose sex was different from theirs; they played less often with other-sex classmates, and were less likely to want to play with children they did not know whose sex was different from their own. Even more remarkably, these effects held up when they were assessed a few weeks after the end of the intervention. These data support other studies that have found that increasing gender saliency led to increased stereotyping in older children (Bigler, 1995).

The message is clear—to reduce sex role stereotyping, reduce the saliency of being male or female.

SEX-LINKED SOCIALIZATION PRACTICES THROUGH THE LIFE SPAN

Young children are often perceived as being untainted by the negative social biases that characterize adults, but many studies reveal that stereotyping and prejudice exist by the age of 4.

Rebecca S. Bigler and Lynn S. Liben (2007, p. 162)

A common theme among the theories of sex role acquisition is that these messages are conveyed in multiple ways, with positive feedback loops increasing the strength of the message. It is clear that the socialization practices we receive vary with age; therefore, a developmental perspective will be assumed in examining this issue. For the purposes of this topic, the life span will be broken up into four broad stages: (1) infancy and preschool, (2) middle childhood, (3) adolescence and young adulthood, and (4) middle adulthood and old age. The most salient aspects of sex role socialization practices in each of these broad stages will be considered. In keeping with the underlying theme that biological and psychosocial influences are inextricably intertwined, readers will be reminded of the possibility of biological-behavioral bidirectional effects at every stage of development. The effects may not be equal at each developmental period, but both operate simultaneously throughout the course of human development.

Infancy and Preschool

The infant departments of retail stores are small worlds divided into colors of pink and blue. Perhaps it is not surprising that the infants for whom we purchase pink or blue booties, rattles, and diaper bags, grow into children who apply gender schemata to organize the world around them into male and female categories.

—Lynn Liben and Rebecca Bigler (1987, p. 89)

Without the trappings of pink and blue booties, it is extremely difficult to tell if an infant is female or male as long as the infant in question is suitably wrapped in a diaper. Perhaps it is because there are so few observable cues that signal the sex of a baby that infants' clothes come color-coded for sex. If you doubt that strong messages about expected behaviors and traits are communicated for boy and girl infants, stop at the "new arrival" card section of any store and look over the words and pictures that announce that birth of a girl or boy. These messages and images are repeated in cards that are sent to congratulate

the new parents. When you visit the homes of infants, look into the baby's room. I have yet to find one where the sex of the infant was not immediately apparent from the furnishings, use of colors, toys, and style of accessories (e.g., frilly versus plain blankets and bedding). Few parents take it kindly if you mistake their infant son for a daughter, or vice versa.

By the end of the first year of life, infants are beginning to categorize people according to their sex (Fagot & Leinbach, 1993). Other group categorizations, such as race, do not occur for several more years. The preference for sex-typed toys appears around 18 months to 2 years (Blakemore, Berenbaum, & Liben, 2009), with boys preferring toys like cars and trucks that involve movement and girls preferring dolls and household objects. Similar toy preferences have been reported for children in Europe and Asia. In Goldstein's (1994) review of children's play, he concluded that girls and boys "play differently and men and women differ in their views of that play" (p. 110). There is some evidence that these preferences are, in part, biologically based. Across several cultures, young boys engage in more "rough and tumble play," which includes play fighting, wrestling, tumbling, and chasing (Humphreys & Smith, 1987).

One theory proposed to explain the early learning of sex role stereotypes is developmental intergroup theory (DIT; Bigler & Liben, 2007). Why do we have stereotypes for some ways of grouping people, such as girls and boys, but not other ways of grouping people, such as being tall or short or right- or left-handed? Developmental intergroup theory answers this question in a three-part model. It is a developmental process that starts in early childhood. First, some group differences are particularly salient. It can be easy to discriminate the girls from the boys because they wear different clothing and have different hair styles when they are very young. Children learn to categorize individuals on the basis of their group membership, so when teachers ask for a boy to erase the board or a girl to take a message to the office, the teachers and other adults are signaling that being a boy or girl is an important type of group membership. Finally, over time, children come to believe that there are "essential" differences between girls and boys—not just differences in their genitals or their clothing, but in how they think and act. This last stage includes developing a bias in favor of one's own group and stereotyped beliefs about members of the other group. These processes have important implications for teachers and often adults who interact with children. To reduce stereotyping, we need to avoid or minimize the way we label and group children according to whether they are female or male.

Middle Childhood

61% of all parents believe that differences in behavior between boys and girls are not inborn, but a result of the way they're raised.

—M. Peyser and A. Underwood (1997, p. 60)

Childhood is the time in life when multiple socializing forces enter the child's life. Although almost any person or institution that children come into contact with can be considered socializing agents, we'll briefly examine three major forces during middle childhood—parents and peers, television and other media, and teachers and schools.

Girls and boys participate in (some) sex-typed activities in childhood. As expected, there is an association between participation in spatial activities and visuospatial abilities (Newcombe, Bandura, & Taylor, 1983). If you are thinking critically (and I hope that you are), you won't be too quick to conclude from these findings that boys necessarily become better at spatial skills *because* they participate in more sports. Although this seems to be a possibility, it is also possible that more boys engage in sports that involve throwing a ball because they are better at spatial skills or for a reason that is unrelated to cognition, such as boys' tendency to have greater upper body strength than girls. The same criticism can be made about a study that found that girls who play with traditional boys' toys tend to perform better on spatial tasks (Serbin, cited in Adler, 1989). It is possible that these girls are able to develop their spatial abilities by playing with traditional boys' toys, but it is also possible that the girls who chose boys' toys are the ones with better spatial abilities. These studies do not explain why boys engage in spatial activities and sports more often than girls do, illustrating the intractable problem of determining cause and effect from naturalistic studies.

A recent model of gender self-socialization describes how stereotypes develop through childhood and beyond (Tobin, Menon, Menon, Spatta, Hodges, & Perry, 2010). According to this model, there are three interrelated processes: gender identity (I am a girl or I am a boy); gender stereotypes (boys play with trucks, and girls play with dolls); and self-attributes (I play with dolls, or I play with trucks). These three components need to be consistent, and the stronger someone identifies with one gender, the more likely they are to bring their own self-attributes into line with the stereotypes about what is appropriate for being a girl or boy. These processes begin in preschool, but continue to strengthen through childhood and throughout life. These three interrelated components are shown in [Figure 6.5](#).

The Importance of Parents and Peers During Childhood

Parental behaviors have no effect on the psychological characteristics their children will have as adults.

—Judith Rich Harris (1995, p. 458)

Parents in western societies believe that they play a major role in shaping their children's lives. It is easy to understand why parents feel strongly about their importance in their children's lives. Parenting is the most difficult job

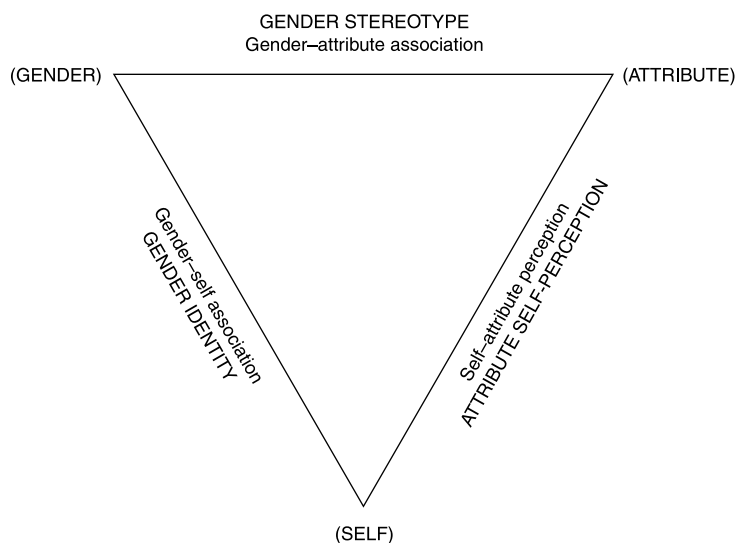


Figure 6.5 Three interrelated processes to explain the development of sex role stereotypes. From Tobin, Menon, Menon, Spatta, Hodges, and Perry (2010). Copyright © 2010 American Psychological Association. Reproduced with permission.

there is. (Okay, I acknowledge that this is a value judgment—one that is shared by millions of parents who have made their commitment to being a good parent their highest priority.) Dedicated parents spend much of their life caring for their children, working hard to support them in multiple ways, often sacrificing their own careers and leisure time for the good of the children. Parenting is hard, demanding work that offers rich rewards for many adults. Thus, it is not hard to understand the firestorm of protest that angry parents lobbied against an influential book and journal article written by Harris (1995, 1998) in which she concluded that parents have little effect on the psychological characteristics of their children beyond the genetic material they contributed at conception.

When *Newsweek* (Begley, 1998) magazine ran a cover story on Harris' conclusion about the puny significance of parents, they received a huge number of angry responses, many from parents who found the very idea that they were not important in shaping their children's personalities to be an anathema. Like other complex issues, the real question cannot be answered with a simple yes or no as to whether parents are important in shaping their children's lives, but when, how much, and what types of effects do parents have on their children (not including inherited predispositions). I assume that Harris means that

parents are relatively unimportant as long as they are acting within a wide range of “normal” parenting behaviors. There can be no doubt that abusive or neglectful parents will have disastrous effects on their children, ranging from physical harm, to severe mental and emotional reactions. Variables like providing appropriate schooling, creating a secure and safe environment, and ensuring adequate nutrition are critically important to the cognitive growth of children, and it is the parents who assure these essentials for the good of their children.

One reason why so many parents are convinced that they have had a major effect on their children’s personalities is that children tend to be similar to their parents in many ways. Harris notes that these similarities reflect “gene–environment” correlations, not the outcomes of parenting behavior. Parents and their biological offspring share some genetic traits and an environment that is responsive to inherited traits. For example, parents who like to read tend to have children who like to read, but not necessarily because the children learned to love books from their parents. Both parents and children may be good readers, with a preference for sedentary activities like reading. Children of parents who love to read will grow up in an environment filled with books and parents who respond to their children’s enjoyment of reading with more books. This theoretical position recognizes that children actively shape their own environment. If, according to Harris (and others who favor a behavioral genetic perspective), parents are not important socializing agents, then where do children learn about sex role stereotypes and other socially mediated roles and rules?

Harris believes that the peer group is important in transmitting these cultural expectations to children. Sex-typed behaviors, consistent with sex role stereotypes, are fostered via the peer group pressures. The sexual composition of the child’s peer group is always important, with sex-segregation especially critical in middle childhood. Harris believes that the single-sex peer groups that are common across many cultures during middle childhood enforce rigid standards about appropriate behaviors for girls and boys. Children are often more concerned about maintaining sex-typed behaviors than their parents are because assimilation into their sex-segregated peer groups requires children to conform to group norms. Kimmel’s (2008) study of preteen and adolescent boys supports the view that same-sex peers enforce sex role stereotypes and punish anyone who strays beyond the boundaries of appropriate sex-typed behavior. This theory is supported by Lytton and Romney’s (1991) conclusion from a meta-analytic review of 172 studies showing that parents engage in surprisingly few sex-differentiated socialization practices. Distinctions between the groups become exaggerated and belief in the superiority of one’s own group is a necessary component of self-esteem for the group. Appropriate areas of cognitive pursuit and excellence are learned and enforced in similar ways by the peer group. Peer groups in middle childhood operate in the same ways

that other groups do—members of the “in group” achieve a favored status; members of the other group, in this case the other sex, are viewed with some hostility and in ways that exaggerate between-sex differences. In order to maintain the separatism of the two groups so that girls and boys know what is appropriate for their sex, members of each group must conform to their own group norms.

Other studies, however, have found a relationship between parents’ actions and attitudes and the “gender beliefs” of their children. For example, in one study mothers’ attitudes toward sex role stereotypes and their comments about gender predicted the attitudes and stereotyping of their children aged 3 to 5 years, but did not predict the attitudes and stereotyping of children aged 6 to 7 years, when children are exposed to the ideas of their peers in first and second grade (Friedman, Leaper, & Bigler, 2007). The underlying idea is that parents are a primary and early source of what children learn about appropriate sex roles, so even if there are few differences in terms of how much parents interact with girls and boys or the warmth, affection, or restrictiveness they show in their interactions with their sons and daughters, there are still many avenues for conveying sex role information (Gelman, Taylor, Nguyen, Leaper, & Bigler, 2004). Thus, it is possible that parents really do tend to treat their daughters and sons in similar ways, but still convey sex-stereotyped messages via modeling and direct discussions.

Television and Other Media

When it comes to stereotyped sex behavior, children more and more put on the cultural cloak that is provided by the society they are growing up in. They use the basic categories ‘male’ and ‘female’ as hooks on which to hang a great deal of cumulative information.

—Eleanor Maccoby (1990, p. 5)

There is ample evidence that sex role stereotypes remain alive and well throughout most (if not all) of the countries of the world and they are repeatedly reinforced via various media. Furnham and Paltzer (2010) reviewed 30 separate studies of sex role stereotyping in television commercials in 20 different countries. The data show the difficulty in cross-cultural comparisons where different countries have different numbers of local and international channels and multiple variables such as time of day, type of product being advertised, and how to analyze commercials—by user of product, authority, credibility, age, proportion of people in a country with access to television, and so on. Despite multiple differences among countries and studies of sex stereotypes in advertising, the general distinction with women expressing warmth and men shown as authorities seems to be cross-culturally reinforced in television and other media.

Teachers and Schools

It would be preposterously naïve to suggest that a B.A. degree can be made as attractive to girls as a marriage license.

—Grayson L. Kirk (president of Columbia University during the 1968 student protests, undated)

Schools are the only institution in our society charged with the exclusive responsibility of educating our children. It is there that the intellectual abilities of all girls and boys should be nurtured so that every individual can develop to his or her full potential. Although public schools in most western countries can no longer require students to take separate courses in drafting and home economics, in fact, most of these classes are still segregated by sex. Despite egalitarian rhetoric (at least in some school districts), some curriculum choices are not real. While I am certain that every reader has his or her own personal examples, I cannot help but recall what happened when my daughter registered for eighth grade (in a Vancouver, Canada, public school). She was told that she could pick either drafting or home economics, but if she chose drafting she would be the only girl in the class and she might find some “resistance” from the boys and their teacher. (Similarly, there were no boys in home economics.) The question is not whether it is better to take drafting or home economics, because both are valuable, but whether one’s biological sex should be the determinant. Why doesn’t everyone need to know about cooking, nutrition, food storage, and how machines work? (If you were wondering about my daughter’s choice, get real. There are very few eighth graders who would risk peer status by doing anything as deviant as taking a sex role inappropriate course.) This is only one of many examples where the rhetoric does not match the reality.

It seems that all of the major socializing agents of childhood act in ways that encourage sex-differentiated cognitive development. It also seems that few of us are aware of the multitudinous pressures to conform to traditional sex roles and of the diverse ways these pressures are communicated to children. Notwithstanding this conclusion, there is much disagreement about the cognitive effects of these subtle and not-so-subtle sex-differentiated messages.

The Angst of Adolescence

The pre-adolescent peer group tends to reject a girl who appears to be too smart or too successful.

—K. D. Noble (1987, p. 371)

Adolescence covers that time in the life span when boys and girls begin to develop secondary sex characteristics and ends when physical maturity is achieved. Considering the variety of individual differences in the timing of

these developmental milestones, it can be roughly operationalized as beginning as early as age 10 and extending to as late as age 18, recognizing, of course, that a few individuals begin puberty before age 10 and a few continue physical maturity after age 18. Adolescence has already been identified in earlier chapters as a critical period in the development of cognitive sex differences. Recall from [Chapter 3](#) that it is during adolescence that boys begin to take the lead in standardized tests of mathematics (usually mathematical problem solving and math that utilizes visuospatial skills) and girls take the lead in writing-related tasks.

The most recent “news” about cognitive sex differences is that boys are underachieving relative to girls. As described in multiple places, females are graduating from high school and college at higher rates than males; but males score higher on most standardized tests, are more likely to work in the prestigious STEM fields, and earn more money than women. The question as to who is “winning” the sex wars depends on whom you ask and what data you include. Popular headlines make it seem “that *all* girls achieve whilst *all* boys fail” (Skelton, Francis, & Read, 2010). In fact, social class and minority status are important determinants of who fails or succeeds. In a study of teens in the United Kingdom, researchers found that high achieving teenage girls felt strong pressure to be “popular,” which meant having “good looks” and wearing fashionable clothes. By conforming to these stereotypes, they could avoid the negative stereotype associated with being a smart teen. Thus, even among the highest achievers, and possibly because they were the highest achievers, teen girls feel intense pressures from sex role stereotypes. I return to the topic of whether there is a “boy crisis” in schooling in [Chapter 8](#).

Body Type and Developing Sexuality

Decades after the feminist movement sought to reduce the emphasis on girls’ looks, guess which type of pageant—scholarship or beauty—is most popular?

—Frerking (January 13, 1997, p. E6)

Although biological definitions of puberty usually cite the development of adult patterns of body hair (the word puberty is derived from a Latin word meaning fine, downy hair), psychosocial definitions of adolescence are more likely to stress romantic interest and concern with one’s changing body. There are profound psychological consequences of the biology of adolescence. The biological events that symbolize the ability to reproduce—menarche for girls and ejaculation for boys—have intense psychological significance. For each sex, these biological events signify that for the first time, the individual, along with a partner, can create life. Friendships with members of the other sex and preadolescent romances assume a new potential meaning when young adults develop sexually.

The biological changes associated with physical maturation have tremendous psychosocial significance. There is ample evidence to believe that girls and boys who attain puberty at an early age and develop adult-like body types before most of their peers are treated differently from their later maturing friends. As described in the preceding chapter, one biological theory to explain cognitive sex differences is that early maturers do not develop spatial skills as well or as fully as later maturing adolescents, possibly because of the effect of sex hormones on brain organization. It is also possible, however, that early maturers differ from late maturers for psychosocial reasons. For example, a study conducted in the United States and United Kingdom found that early maturing students were more likely to smoke, and there was no evidence that their later maturing peers catch up to them in the rate of smoking (van Jaarsveld, Fidler, Simon, & Wardle, 2007). Early maturing girls reported higher levels of stress than later maturing girls, but this effect was not found for the boys. The researchers concluded that “early maturation may be a cause of, or is at least a marker for, differences in lifestyle” (p. 798).

Early maturing boys are more muscular and taller than later maturing ones; therefore, they experience greater peer group prestige (Hamburg & Lunde, 1966). There are numerous secondary gains from their physical stature. Their height gives them a competitive edge in sports such as basketball, volleyball, long jump, and soccer. The early growth of body hair allows them to cultivate a moustache while still in junior high school, and their developing biceps are likely to receive positive comments.

Puberty rate differences are even more pronounced for girls, who soon learn that their “hour-glass” figures and growing breasts make them desirable dates and mates. They undoubtedly receive more attention from males, especially older males, than their less shapely girlfriends.

Adulthood and Old Age

The average American woman spends 17 years raising children and 18 years helping aging parents.

—*Newsweek* magazine (July 16, 1990, cover)

The bulk of our lives are spent as adults and later as older adults. There are numerous psychosocial factors that maintain the sex role stereotypic behaviors we learned in our youth. Below is a brief survey of some of the factors that have implications for cognitive functioning.

Sex-Related Power Differential

Married women with more than three kids recorded an average of about 28 hours of housework a week, while married men with more than three kids logged only about 10 hours of housework a week.

—Bobbie Mixon (2008)

It is possible that psychologists who study cognitive differences are missing the most salient aspect of sex differences in human interactions. Rudman and Glick (2008) believe that many sex differences are an artifact of power and status differences. Men behave as they do because they hold substantially all of the real power in society, and women behave as they do because they are much less powerful than men. Men gain power and prestige through the status of their occupation and the size of their paycheck (Kimmel, 2008). Occupations that are typically male are more highly prized by society than occupations that are typically female. Even when a traditionally female and a traditionally male job require the same level of background or training (e.g., secretary and groundskeeper), the male job will most often pay substantially more.

Most of society's powerful people are men. Despite women's success in education and mid-level management, few women make it to the "O" level—CEO, CFO, CIO, CTO—in the corporate world or comparable top levels in noncorporate settings, such as the highest levels of political office, or top rungs of the academic ladder. In the United States, women held 13.5% of executive officer positions in Fortune 500 companies, but only 2% of the chief executive officer positions (Catalyst, 2010a). They also comprised 7.6% of the 2010 Top Earners. Virtually all government leaders, corporate officials, leading scientists, bankers, and stockbrokers are men. Society's power differential continues in most households. Even if men are no longer the sole breadwinner, in a vast majority of American households, the majority still earn more than their wives. In most marriages, the husband not only earns more money, but he is also better educated, taller, and heavier than the wife. Thus, the power differential extends beyond money and prestige of occupation, it also includes the physical power associated with larger stature.

The occupations that require spatial and mathematical abilities frequently offer higher prestige, power, and higher salaries. Children learn that if they want to become engineers, computer analysts, accountants, or scientists, they will have to excel in mathematics and sciences. Since these are examples of the high paying prestigious occupations that are primarily filled by men, boys learn that success in the academic areas that are prerequisites for these occupations is necessary if they are to fulfill their adult sex role. There are some occupational trends that buck the trend. For example, 61.8% of all accountants and auditors are women, so clearly women have the ability to succeed at math-intensive professions (Catalyst, 2010b). The only conclusion that can be reached is that many prestigious, high paying jobs require mathematical and spatial skills and that some, but not all, of these jobs tend to be filled primarily by men. However, it is important to remember when considering the relationship among ability, occupation, and sex that more than ability is involved in determining who fills the high status occupations. Traditionally, other demographic indicators like race, socioeconomic status, religion, and country of origin, independent of ability, have determined who will succeed in high status positions.

Achievement Motivation

Another possible explanation for the cognitive sex differences that are typically found is that they do not represent ability differences. Instead, it is possible that they are indicators of motivational differences. It is possible, for example, that women and men are equally able to learn higher level mathematical concepts, but for some reason, men are more motivated to put in the hard work needed to learn the concepts and/or more motivated to demonstrate their knowledge. This is an older hypothesis that was extremely popular in the late 1960s and 1970s. Horner (1969) examined the possibility of sex differences in academic motivation. She asked college students to complete the following story which concerned a protagonist named either Anne or John: "At the end of first-term finals, Anne [John] finds herself [himself] at the top of her [his] medical school class." She found that college students wrote about many more negative consequences of academic success for the female protagonist than for the male protagonist. Examples of some of the negative consequences that followed Anne's success were: "Everyone hates and envies Anne" and "Anne feels unhappy and unfeminine." It seems that the female protagonist had become unsexed by success. These results led Horner to hypothesize that, in addition to the usual motivational tendencies that are found in both men and women, women possess a fear of success or a motive to avoid success because success often has negative consequences for women.

Although Horner's research on fear of success captured media headlines, it has not held up in replications and currently has historical status. Currently, medical school graduates are 50% women, so the stereotype that medicine is a male-typical profession should fade. Like most psychological constructs, success motivation is more complex than a simple approach-avoid continuum. It seems that we also need to be concerned with "success at what?" Later research showed that there was little negative imagery when Anne was successful in traditional female occupations like nursing. In addition, males have also been found to be concerned with negative consequences of success. More recent research suggests that if fear of success is a valid motivational tendency, then it exists about equally in men and women. It seems that while many women may want to become more than just a "sex object," many men want to become more than just a "success object." Thus, the well-publicized fear of success motivation cannot be used to understand cognitive sex differences.

CHAPTER SUMMARY

A psychosocial perspective assumes that the psychological differences in the lives of women and men are largely constructed by society. Proponents of psychosocial explanations often prefer the term "gender" to the term "sex" to

signify the societal origins of sex differences that are unrelated to the biology of reproduction. Psychosocial explanations of cognitive sex differences are important because of their implications for change. If sex differences in cognitive abilities can be attributed to psychosocial variables, then these changes can be reduced or eliminated with appropriate societal changes. One of the difficulties in identifying the relevant psychosocial variables is the pervasiveness of sex role stereotypes in our society and the inability to make causal statements from correlational data. Another difficulty is created by the nonconscious ideology which may have blinded us to many of the sex-differentiated attributes and expectations that have become ingrained in contemporary society.

Sex role stereotypes, those beliefs about the ways females and males differ and should differ, do not represent two distinct categories. Instead, they consist of traits, behaviors, and dispositions that are more or less statistically associated with being male or female. The complexity can be seen in the multiple ways positive and negative traits are associated with one sex or the other and either permissible or proscribed for one sex or the other. Stereotypes show considerable overlap on many dimensions. In addition, there is considerable evidence that the stereotypes are frequently accurate in that they correctly assess the statistical differences between females and males and are sensitive to context variables.

There are many differences in the interests, values, and activities of males and females in contemporary western society. At every age, the sexes spend a large portion of their time in sex-differentiated activities ranging from experiences and expectations in infancy, type of play in childhood, courses selected in high school, career choices in early adulthood, time spent in child and elder care in adulthood, and life expectancy into old age.

In general, females are more concerned with communal values and prefer to work with people; males are more concerned with agentic values and prefer to work with "things." Some researchers have suggested that these differences in values and preferences are the reason why STEM fields are primarily male. There is intense disagreement among psychologists and others about the role and relative importance of socializing agents in the creation and maintenance of sex role stereotypes. In general, parents believe that children learn sex role behaviors and that they, the parents, do not treat their sons and daughters very differently. Yet, despite these beliefs, there are many indicators that sex role expectations are communicated by parents and others in a variety of subtle and not so subtle ways.

Stereotypes can depress performance for members of any group associated with a negative stereotype when that negative stereotype is activated, which is called "stereotype threat." Results from meta-analyses show that sex differences in standardized math tests could be reduced if stereotypes were not made salient at the time of testing. Stereotypes are conceptualized as part of a network of concepts that are stored in long-term memory. Activation occurs

when the negative stereotype is made salient, when performance on the task is important to the individual, and when the task is difficult. When gender is made salient over a period of weeks, children show increased rigidity in the stereotypes and adhere more strongly to stereotyped behaviors and preferences. There are numerous demonstrations that stereotypes can affect performance without conscious awareness. For example, stereotyped associations can be inferred from the Implicit Association Test, which measures reaction times to categorizing terms in sex role congruent and incongruent ways. Stereotypes can be powerful forces because they can operate automatically, without the belief that the stereotype is true, and without conscious awareness. Attempts at reducing the stereotype effect have been successful. It is also true that most people are fairly accurate in their beliefs about sex differences in cognitive abilities, a finding that challenges the idea that stereotypes are inaccurate exaggerations of real differences, but they are nonetheless harmful because they are inaccurate about the large number of people who do not conform to the stereotype and they are difficult to change.

A developmental life span approach was used to show how each age has particular implications for learning and using sex role stereotypes and the way these beliefs can be influencing cognitive sex differences. Sex role stereotypic messages and pressures can be found throughout the life span.

Psychosocial Hypotheses Part II: Theoretical Perspectives for Understanding the Role of Psychosocial Variables

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Gender roles mandate different primary activities for women and men. Women are supposed to support their husband's careers and raise their children; men are supposed to compete successfully in the occupational world in order to confirm their worth as human beings and to support their families.

—Jacqueline Eccles (1994, p. 600)

A wide variety of psychosocial variables implicated in creating, maintaining, or increasing sex differences in cognitive abilities was presented in [Chapter 6](#). Harris (1998) referred to the belief that psychosocial factors are (primarily) responsible for the differences in the lives of males and females as the “nurture assumption.” As discussed in [Chapter 6](#), part of the appeal of assuming that differences in sex roles are caused by variables near the nurture end of the nature–nurture continuum is that nurture variables are rooted in societal practices and societies can change. But, like most dichotomies, the idea that environmental effects can be easily altered and biological ones are immutable is wrong. Hormones, for example, are easily manipulated, and some environmental variables, such as societal beliefs, are very difficult to alter. Thus, just as biological factors do not suggest determinism; social factors are not necessarily easily changeable.

A psychosocial perspective raises interesting questions. Would females and males become more similar if they were treated the same way? For example, parents who spank their son for some misbehavior, but send their daughter to her room without supper for the same misbehavior, are sending a strong sex role stereotypic message to all of the members in the household. The message is clear—even when the behavior is the same, girls and boys are treated differently, and there are different expectations for girls and boys, different beliefs about what is appropriate, and different consequences for the same actions. This message is reinforced by viewing tens of thousands of hours of television shows, over many years, that depict sex-typed characters and themes. Outside the home, children encounter teachers who pay attention to girls and boys for different reasons and peers who enforce different rules for girls and boys. Evidence of sex role stereotypes can be found throughout the life span. But how do sex role stereotypes arise? Why do they persist? How easily or quickly could they be changed? What would a society be like if the lives of women and men became more similar? Many theorists have used questions like these as a starting point for theories that can help us to understand, predict, and perhaps, even manipulate those psychosocial variables that are implicated in cognitive sex differences.

A THEORY OF THEORIES

Parents' gender associations are firmly in place well before a child is a twinkle in daddy's eye. The scant but suggestive data . . . hint that beliefs

about gender—either consciously or unconsciously held—are already shaping expectations about a future child’s interests and values, already biasing the mother’s perception of the little kicking baby inside her, and are already molding a mother’s communication with her unborn child.

—Cordelia Fine (2010, p. 194)

Making sense out of the host of psychosocial variables that could be influencing the cognitive development of males and females in sex-differentiated ways is a tough job because many different types of variables are interwoven into the fabric of society. There are multiple possible perspectives for organizing the psychosocial world. A “theory of theories” is needed to organize the many theories applied to questions about cognitive sex differences. I like to think about the quest to understand cognitive sex differences as analogous to the well-known parable of the three blind men and the elephant. It is a story that is probably familiar to most readers. In this parable, each blind man attempts to “know” what an elephant is like the only way he can—by using his sense of touch. One blind man is certain that an elephant is broad and strong like a tree; he is feeling the elephant’s leg. Another is certain that it is small and thin like a reed; he is feeling the elephant’s tail. The third blind man cannot understand how the others can be so blind, when the elephant is surely flexible like a hose; he is feeling the elephant’s trunk. Which of these blind men is correct? In part, they all are, and of course, in part they are all wrong. Perhaps this is a good metaphor for understanding the varying theoretical perspectives on cognitive sex differences. Each of the psychosocial theories frames the question of cognitive sex differences in a somewhat different way, and each takes a different view of what is important and how and why the differences came about. Not surprisingly, each provides a “piece of the answer.”

Several different theoretical positions are considered in this chapter: (a) the psychoanalytic view associated with Sigmund Freud; (b) learning theories that posit general mechanisms for learning; (c) social learning theories that emphasize the importance of appropriate role models; (d) social ecology, an approach that emphasizes the contextual nature of sex role behaviors; (e) cognitive schema and social cognition theories that highlight the thinking processes; (f) the expectancy-values-motives perspective where motivation and individual choice are of primary importance; (g) a “bent twigs” theory where biological predispositions are enhanced by society; (h) cultural influences; (i) the conflict between women’s preference for family and children over time-intensive careers; and (j) performance and strategy variables that explain cognitive sex differences as being more similar to habits than abilities. These diverse perspectives mirror the many subfields of psychology—each with a different emphasis and a different view of what is important in understanding the complexity of human nature.

THE PSYCHOANALYTIC PERSPECTIVE

The psychic development of the individual is a short repetition of the course of development of the race.

—Sigmund Freud (quoted in Bartlett, 1980, p. 678)

Over 100 years ago, Sigmund Freud proposed an influential theory that encompassed developmental psychology, psychopathology, psychotherapy, and personality. Freud is probably the most famous psychologist who ever lived, in part because his views were so radical, and, in part, because he influenced many of psychology's subdisciplines with a single, broad theory known as "psychoanalytic theory." Freud's ideas have had a profound impact on developmental ideas and the lay public's views, especially his emphasis on the importance of early development and the way children develop their identity. The foundation of Freud's psychoanalytic theory was built upon the biological differences between the sexes, thereby representing a strong form of the belief that "biology is destiny." He was a prolific and popular writer, with much to say about a wide range of topics, including the ways in which girls and boys develop in psychologically sex-differentiated ways. Freud's contributions to psychology need to be understood in the historical context in which he lived. Psychology was in its own infancy when Freud theorized about the causes of a wide range of human behaviors and emotions. His early work was conducted during the Victorian era, which was a sexually oppressive historical period, so Freud's early emphasis on sexual issues as the cause of psychological problems was readily accepted given the tenor of the times in which he lived.

Many of Freud's main tenets are as important today as they were when he first articulated them. Freud strongly believed that what happened to individuals during their childhood had life-long effects. This idea can be found in William Wordsworth's poem, *The Rainbow*, in which he wrote, "The child is the father of the man." Freud was also among the first to recognize the importance of a child's identification with same-sex adults, a topic that I return to later in this chapter. There is a long list of contemporary topics in psychology that originated in Freudian theory. Most of Freud's original ideas have been substantially modified since Freud's time, including the notion that there are unconscious influences on how we think, act, and behave; and other ideas of Freud have been discarded.

Unlike the other psychologists whose work is reviewed in this book, Freud did not conduct research to determine if his theories were supported with data. For this reason, many psychologists who emphasize the scientific bases of the discipline see Freud as a historical figure, who has little relevance to modern psychology. Others argue that Freud's profound influence on the early development of psychology cannot be minimized and that his views continue to influence psychological thought.

Psychosexual Stages of Development

One of the major tenets of Freud's psychoanalytic theory is that girls and boys proceed sequentially through a series of developmental stages, each important in shaping sex-differentiated behaviors and feelings. Freud named these stages *psychosexual* because female and male differences in their sexual nature were viewed as primary determinants of psychological development. These stages highlight the importance of early life experiences on adult development, a major contribution of Freudian theory. According to Freud, if an individual could not resolve important issues in any of the stages, he or she would develop life-long personality characteristics that were associated with the unresolved issues in that stage.

The core concept in Freudian psychoanalytic theory is that children come to identify with their same-sex parent, and through identification they imitate the appropriate sex role behaviors of their mothers or fathers. The first of these stages, the *oral stage* of development, begins at birth and continues until age 2. In the first two years of life, infants learn the pleasures of oral activity by sucking, first for nourishment and later for the pleasure it brings. Between the ages of 2 and 4, children pass through the *anal stage*, where they learn the pleasures of urination and defecation. The third psychosexual stage is particularly important in understanding sex-differentiated behaviors that occur later in life. Freud maintained that all children at approximately 4 to 5 years of age enter a developmental period known as the "phallic stage," so named because of their preoccupation with their genitals. (Freud used the term "phallic stage" to refer to the development of both girls and boys even though the term "phallic" is derived from a Greek word meaning "penis.") Children in the phallic stage go through a fairly involved sequence of parental alliances and jealousies that follows different paths depending on whether the child is a girl or a boy. It is during this developmental period that children resolve their early feelings of love and hate for their parents and ultimately identify with the same-sex parent.

Let's first consider this process for boys because it is somewhat less complicated than the process Freud attributed to girls. The impetus to identify with their same-sex parent for boys is the "Oedipus complex," named for a 5th century BC play by Sophocles called *Oedipus Rex*. In this play, Oedipus unknowingly commits the unspeakable crime of killing his father and later marrying his mother and fathering children with her. (He did not know they were his parents until after he had committed these acts.) Freud believed that this story represented a universal theme of all boys' sexual longing for their mother. During the phallic stage, the young boy's newly discovered erotic feelings are vaguely directed toward his mother (or mother substitute), because she has been the source of pleasure in the past. At the same time, he also begins to feel jealousy toward his father, a "rival" for his mother's love. This is also the time in his development when he learns that girls do not have a penis, leading

him to conclude that it must have been cut off for some terrible reason. Whatever the reason, the inference is that the female genitalia are lacking something important. He then reasons that the same thing could happen to him because of his sexual desire for his mother and his jealousy of his father. All boys at this age must resolve the problem of “castration anxiety” (an unconscious fear of being castrated). Boys resolve this dilemma the only way possible; they repress their erotic feelings for the mother and identify with the father.

How do girls come to identify with their mothers according to Freudian theory? There is a roughly analogous version of the Oedipus complex known as the “Electra complex,” but its resolution is not as clearly explained as the Oedipus complex was for boys. Electra was the heroine in a Greek tragedy who convinced her brother to kill their mother, also a supposedly universal theme. During the preschool years that comprise the phallic stage of development, girls discover that they do not have a penis and immediately develop “penis envy,” an intense desire to have male genitals. For reasons that Freud never clearly explained, the girl concludes that she must have once had a penis, which was “removed” for some unknown reason. She holds the mother responsible for this sad state of affairs when she realizes that the mother also lacks the prized organ. Girls then turn to their fathers, and, like their brothers, have to resolve feelings of hatred and jealousy. Because of fear of reprisal from jealous mothers, girls shift their identification back to their mothers and imitate female sex role behaviors.

Thus, for Freud, the key to sex role identification is the presence or absence of a penis during critical years of child development (approximately 4 to 6 years old) and the appropriate resolution of the Oedipus or Electra complex. Freudian theory is actually much more complex than this, but these are the basic assumptions underlying sex role identification. He acknowledged that his understanding of the psychology of women was rudimentary, which is why he called women a “dark continent.” Freud described his frustration over his failure to understand women this way:

The great question that has never been answered and which I have not yet been able to answer, despite my thirty years of research into the feminine soul, is “what does a woman want?” (as cited in Masling, Bornstein, Fishman, & Davila, 2002, p. 329)

There are numerous problems with the sex-differentiated aspects of Freudian theory. Most notably, research has shown that a large proportion of children in this age range do not have a conscious understanding about the anatomical differences between women and men (Katcher, 1955). Psychoanalytic theory has also been criticized for its anti-female (penis-centered) orientation, especially for its assumption that children of both sexes immediately perceive the superiority of male genitals over female genitals. In addition, it implies that children who are raised in homes without a same-sex parent will fail to develop sex role appropriate behaviors. Research with children in single-parent families

has shown this prediction to be false (Lynn, 1974). Research with children raised by lesbian and gay parents also shows that these children develop sex role appropriate behaviors (American Psychological Association, 2005).

At the end of the phallic stage, children of both sexes enter a *latency stage* during which time their sexuality is dormant, and children focus their energies on the learning tasks that are important in middle childhood. At puberty, the sexual desires that marked the phallic stage reemerge, but at this stage, sexual desire is focused on other (opposite) sex peers instead of the other-sex parent. Thus, it is identification with the same-sex parent that causes boys to emulate their father's behaviors and girls to emulate their mother's. According to Freudian theory, the most critical developmental period for identification with the same-sex parent occurs during the preschool years.

Some feminist scholars have reinterpreted Freud's statements. For example, Chodorow (1989) argued that penis envy really is a "symbolic expression of women's culturally devalued and underprivileged position in our patriarchal society; that possession of a penis symbolizes the possession of power and privilege" (p. 193). She directly contradicted the idea that sex differences revolve around castration anxiety and girls' longing for a penis. Some feminist theorists redefined central Freudian concepts as arising from culture (Benjamin, 2002); others rejected the basic premises outright.

LEARNING THEORIES

In almost every case, exposure to spatial test materials, or training on related materials, raises spatial ability test scores.

—MaryAnn Baenninger and Nora Newcombe (1995, p. 365)

In the generic sense of the term, all of the theories being described in this chapter can be described as "learning theories" because they are all concerned with understanding the way sex-related behaviors, beliefs, and stereotypes are learned. Learning theory, however, has a very specific meaning in psychology. It refers to the theory that most learning is contingent upon the rewards and punishments that follow behavior. Although terms like "reward" and "punishment" have an intuitive, everyday meaning, they have a precise meaning in the jargon of learning theory. A reward is anything that will increase the probability of a particular behavior, and a punishment is anything that will decrease the probability of a particular behavior. Although learning about appropriate behaviors and stereotypes derives from the same experiences, according to learning theorists, rewards and punishments shape behaviors; learning about stereotypes is a different process that follows from learning which behaviors are expected for boys and girls. We are all familiar with sex role statements like, "Boys don't cry" or "lady-like behavior." It's easy to imagine how rewards and punishments could function to create and reinforce sex role appropriate behavior.

Rewards and Punishments Shape Future Behaviors

Rewards and punishments can assume many different forms. A smile, pat on the back, award, or candy could all functionally serve to increase desired behavior. Similarly, a frown, scolding, physical punishment, or public humiliation could all serve to discourage or decrease the likelihood of a behavior. As children grow, they receive numerous rewards and punishments from parents and other socializing agents who want to influence their behaviors. In a learning theory conceptualization of the origins of cognitive sex differences, the emphasis is on the overt behaviors that children engage in and their consequences. Children and adults receive rewards and punishments for certain intellectual activities, repeating those that are rewarded and avoiding those that are punished. In this way, we all learn from repeated experiences.

According to this perspective, it is likely that a sex-differentiated pattern of rewards and punishments could be used to explain sex differences in verbal and visuospatial ability, with girls encouraged to read more often than boys and boys encouraged to engage in spatial activities (blocks, tinker toys and other construction toys, etc.) more often than girls. Thus, according to learning theory, through sex-differentiated rewards and punishments children learn that mathematical and spatial activities are more appropriate for boys and that reading and other verbal activities are more appropriate for girls.

Practice and Feedback

[A] spatially enriched education could pay substantial dividends in increasing participation in mathematics, science, and engineering.

—David H. Uttal, Nathaniel G. Meadow, Linda L. Hand, Alison R. Lewis, Christopher Warren, and Nora S. Newcombe (under review)

For most people, learning is an inevitable consequence of living (the exception being individuals with extremely low intelligence). With appropriate instruction and experience, everyone will improve in all of the areas in which sex differences in cognitive abilities are found. These are all educable areas of human cognition. There are many studies showing that both females and males, at every age, can improve their cognitive performance on any task if they receive appropriate instruction, which includes feedback or knowledge about their performance. Uttal and his colleagues (Uttal et al., under review) conducted a meta-analysis of 217 research studies investigating the size, moderator, and generalizability of training on spatial skills. There are several reasons why this is an important review in understanding cognitive sex differences. Sex differences on visuospatial skills (the researchers used the more generic term “spatial skills” to refer to the same skills) have been found in infants as young as 3 months (Quinn & Liben, 2008); they are among the

largest of the sex differences (Geiser, Lehmann, & Eid, 2008); they are found into very old age (Jansen & Heil, 2010); they are an important predictor of interest in and success at STEM (science, technology, engineering, and mathematics) fields (Wai et al., 2009); and they are not a formal school subject. Can training improve spatial skills? The meta-analysis by Uttal et al. answered this question with a clear “yes.” “Our results clearly indicate that spatial skills are highly malleable” (Uttal et al., under review). Training programs overall produce an effect size equal to 0.53. (The authors used a slight variant of Cohen’s d to compute effect sizes. The reader can consider the value they provided as similar to Cohen’s d , which was described in [Chapter 2](#).) Moreover, the effects of training were long-lasting and transferred to visuospatial tasks that differed from the ones used in training—in other words, participants improved overall in their ability to work with visuospatial information.

It is interesting to note that even among college students with exceptionally high academic achievement who are enrolled in science and technology majors, there are large sex differences in several different tests of visuospatial abilities (Miller, Halpern, & Saeta, 2010). When both male and female students were randomly assigned to a visuospatial training program that had been designed for engineering students (Sorby, 2009; Sorby & Wysocki, 2003), students improved so much that they scored near the top on tests of mental rotation and imaging what an object would look like if it were cut at irregular angles. [Figure 7.1](#) shows a sample worksheet from the training program. Given

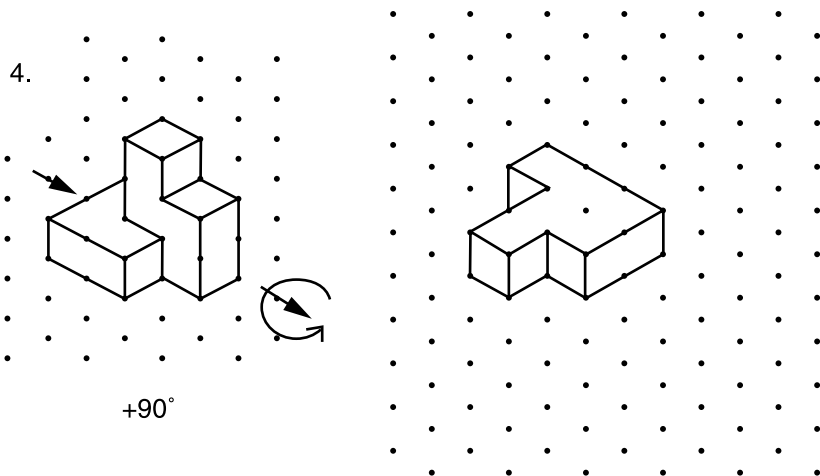


Figure 7.1 Sample worksheet used to train STEM majors in visuospatial skills. In this example, students had to sketch the figure on the right, which is a 90 degree rotation of the figure on the left. From Sorby and Wysocki (2003). Reprinted with permission from Cengage Learning.

the importance of visuospatial skills for success in STEM fields (Kozhevnikov, Motes, & Hegarty, 2007), one clear recommendation is to provide visuospatial skill training as a means of increasing women's participation in these fields and as a means of enhancing the skills of men and women (Halpern, Aronson, Reimer, Simpkins, Star, & Wentzel, 2007).

Learning From Video Games

New methods of cognitive training based on action video games could help to maintain, or even improve, spatial cognition as we age. . . . Video games are not just for kids any more.

—Ian Spence and Jing Feng (2010, p. 102)

Recall from [Chapter 6](#) that males spend many more hours playing video games than females do (Spence & Feng, 2010). What, if anything, are the males learning from these games? One common finding is that video game players tend to outperform those who do not play video games on several different measures of visual attention (e.g., ability to ignore an irrelevant stimulus; Castel, Pratt, & Drummond, 2005). But findings like these do not necessarily imply that playing video games *caused* players to be better at tasks like visual attention, because it is possible that people who have better visual attention prefer to play video games. Readers should recognize that if we were to infer that playing video games improved skills from these findings, we would be confusing correlation with cause. Playing video games and having better visuospatial skills go together, but we cannot use these data to infer cause. This important distinction was explained in [Chapter 2](#). If you are unsure about why we cannot infer cause, be sure to reread the section on correlation in [Chapter 2](#). Researchers have, however, designed experiments to test the causal relationship between playing video games and visuospatial skills (such as visual attention). Research has shown that when participants who usually did not play video games were assigned to play different types of video games, they developed better visual attention, especially when they were trained with difficult video games (Green & Bavelier, 2003). Thus, we can conclude that video game players develop greater visual attention resources as a result of their game playing.

Of course, there is great variety among video games, and different types of games develop different types of skills (Spence & Feng, 2010). Some of the characteristics of different games include mentally rotating a figure, finding one's way, switching tasks, selecting objects, reacting rapidly, switching attention, ignoring irrelevant stimuli, and multitasking. So it is important to consider what is being trained with different video games. The relationship between spatial skills and video game playing is important in understanding the large differences between females and males on many visuospatial tasks. For example, a study conducted in Germany found that not only are women less

likely to play any video games, but among those who play, women are more likely to play games that train logic and problem solving and men are much more likely to play action–shooter games (Quaiser-Pohl, Geiser, & Lehmann, 2006). So merely knowing how often someone plays video games will not tell you about the types of skills being developed by these games.

In one study (Feng, Spence, & Pratt, 2007), researchers measured visuospatial attention using the uniform field of view task (UFOV). In this task, participants view a computer screen where a dark circle appears for a very short time interval (0.1 to 0.3 seconds) and the target is then replaced with some distracting lines. The task for the participant is to click on the screen to indicate where the target appeared. In general participants who played video games were better at remembering where the stimulus had appeared than those who did not play video games, but among the players and nonplayers, females performed worse than males in each group. The surprising result was that after only 10 hours spent playing a video game that develops the ability to remember where things appear on a computer screen, the sex difference in the UFOV task was eliminated, although I need to urge caution in interpreting these results because the sample size was very small, which makes findings of differences less likely. In addition to the UFOV, these researchers also had all participants take the mental rotation task that was described in [Chapter 3](#). Sex differences in the mental rotation task were reduced, but not eliminated, after training with video games. Given that training lasted only 10 hours, we can only guess at the difference that might have resulted from hundreds of hours of play.

Computer Games Can Enhance Visuospatial Working Memory

Researchers have been looking for the locus of sex differences in cognition—the place in the information processing system where females and males differ. For example, in the Feng et al. (2007) study that was just described, researchers found that there are sex differences in visuospatial memory—how well people remember where objects appear in space when they are flashed on a screen for a fraction of a second. The reasoning behind studies like this one is that they can allow us to find where sex differences occur in the flow of information from perception to action. A similar approach was used by Kaufman (2007). Recall that psychologists conceptualize cognitive processes as starting with perception, followed by working memory, and then into long-term memory. Working memory is divided into several parts—one part corresponding to verbal information and another part corresponding to visuospatial information. There is also a part of working memory for situational variables (where something was learned, for example) and for personally meaningful information, called the episodic buffer (Baddeley, 2000).

As reviewed in [Chapter 3](#), females tend to have better episodic memory than males do. They also excel on some verbal tasks (e.g., writing, fluency in naming

examples of a category such as types of food), whereas males tend to excel on many visuospatial tasks. Kaufman wondered if the male advantage on tests like mental rotation reflected differences in visuospatial working memory. To test this prediction, he gave a sample of young men and women (aged 16 to 18) several different tests and measures of visuospatial working memory. He replicated the usual findings of a very large sex difference in mental rotation ($d = 1.01$) and a large sex difference, also favoring males, on another visuospatial test called the Differential Aptitude Test for Spatial Relations ($d = 0.42$). He also found large sex differences favoring males on two different measures of visuospatial working memory ($d = 0.65$ and $d = 0.58$). He then used a statistical technique known as structural equation modeling (briefly described in [Chapter 3](#)), which allows researchers to determine, for example, if the differences that were found in the visuospatial tests could be “explained” by the differences in visuospatial working memory. He found that sex differences in visuospatial working memory are responsible for some, but not all, of the sex differences in the visuospatial tasks.

SOCIAL LEARNING THEORY

Math class is tough; I love dressing up; Do you want to braid my hair?

—Teen-Talk Barbie’s first words

Attack the Cobra Squad with heavy fire power; When I give the orders, listen or get captured.

—GI Joe, quoted in Viner (1994)

Several prominent theorists have proposed that sex-typed behaviors are learned in multiple ways (Bandura & Walters, 1963). They believe that while direct rewards and punishments can produce sex role learning, imitation learning or modeling may be the more important mechanism for producing sex role appropriate behaviors. This theoretical perspective is many decades old and has a large research literature. Because of the importance psychologists attach to imitation or modeling in social situations, this theory is sometimes called social learning or social modeling. In addition to receiving rewards and punishments for behaviors that are either consistent or inconsistent with sex roles, children are also told in numerous ways that they are either a girl or a boy. Children also notice similarities among other girls and among other boys. A list of possible examples would be quite long: Girls may wear bows and barrettes in their hair, but boys may not. Girls may wear almost any color clothing, while boys may not wear pink clothes. Very few boys will own doll carriages, a common girl’s toy. Combat dolls like GI Joe and play guns and rifles are appropriate for boys, but not for girls. In fact, these “dolls” are frequently called “action figures,” so that they are distinguished from the sort of dolls that elicit care-taking play. GI Joe, “the Hulk,” and similar “action

figures” are not designed to encourage the same play activities as “Betsy Wetsy,” a doll who sucks from bottles and needs to have her diapers changed, and “Chatty Cathy,” a doll who talks all the time. (These are the real names of popular dolls. I leave it to the reader to consider whether the Hulk is as demeaning as a doll that talks nonstop.)

There are also obvious differences among adults who model grown-up behaviors. Women may wear high heeled shoes, panty hose, make-up, nail polish, and dresses, while any man who wears these items is considered deviant. Men may wear wing-tipped shoes and men’s style clothing. Anyone who doubts that there are strong sanctions about something as simple as clothing-type should try to shop for shoes in the shoe department reserved for the other sex. The message that some shoe styles are appropriate only for women or men was probably never stated explicitly, but it was made clear just by observing. If you are a woman, you did not have to try to purchase shoes in the men’s shoe department, or if you are a man, you did not have to try to purchase shoes in the women’s shoe department to learn what is appropriate for your sex.

Observational Learning

Same-sex modeling can promote same-sex differentiated patterns of behavior.
—Kay Bussey and Albert Bandura (1984, p. 1292)

According to social learning theory, children learn about sex role behaviors by observing between-sex differences as they are played out in the lives of the other children and adults with whom they interact and in the media. They then imitate the behaviors and attitudes of same-sex models. Social modeling theory differs from learning theory in that it does not assume that rewards and punishments must be received in order to shape behavior or that the child personally engages in the behavior. Sex role learning can occur from observing others and imitating them. Appropriate imitation is likely to be rewarded, as in the case of a young girl who dresses up in her mother’s shoes and old dresses. Inappropriate imitation is likely to be punished, as in the case of a young boy who dresses up in his mother’s shoes and old dresses. Thus, through a combination of observational learning, appropriate modeling, and rewards and punishments received both by the role models and the children in their attempts to imitate the models, boys and girls learn society’s sex roles.

An interesting implication of social learning theory is that much of the learning is done by watching others, which means that sex role messages can come from a variety of sources outside of the home. Even if parents did not differentially socialize their children based on each child’s sex, there are still many opportunities for children to learn about sex-typed behaviors including those presented on television, in school classrooms, on the playground, and in the homes of others. These messages can even be learned from Barbie dolls and GI Joes and the various characters found in video games, books, and other media. With messages

about appropriate female and male behavior coming from so many different sources, these messages would be almost impossible to ignore.

Psychologists in the United States recently studied how modeling would influence achievement in mathematics of first and second grade children from a variety of schools (Beilock, Gunderson, Ramirez, & Levine, 2010). They began with the premise that young students model the behavior of same-sex adults more often and more closely than adults of the other sex. If this premise is valid, then what is the effect on girls and boys of having over 90% of all elementary school teachers being female? To answer this question, the researchers first determined how anxious a sample of elementary school teachers was about mathematics. At the start of the school year, girls' and boys' mathematics performance was unrelated to how anxious their teacher felt about mathematics, but by the end of the year, girls with teachers who were anxious about mathematics were more likely to agree that "boys are good at math and girls are good at reading" than children whose teachers were not anxious about mathematics. The teachers must have communicated their anxiety about mathematics to their class in multiple ways, including nonverbal behaviors such as facial expressions and perhaps even verbally by expressing comments about mathematics being hard. The researchers concluded that little girls learn to fear mathematics from their earliest teachers. In addition, girls who endorsed sex stereotypes about mathematics and reading scored lower on tests of mathematics than girls who did not endorse these stereotypes. The boys were not affected by how anxious their teacher was about mathematics, presumably because they are less likely to see their female teachers as role models. The surprising result was how strong the effect was for girls and the absence of an effect for boys. These results also show that observational learning is a key element in gender development (Martin, Ruble, & Szkrybalo, 2004).

Social modeling is not restricted to the acquisition of sex roles in childhood. As adults, we also observe how each sex should act, imitate appropriate models, and receive rewards and punishments for these actions. We are social animals who frequently look to others to determine how we should act and what we should think and feel. We are most likely to adopt the behaviors and attitudes of those who are similar to us. Social influences to conform to behaviors deemed appropriate by society are extremely strong, even for adults. For example, few women would feel comfortable as the only female in an all-male class on motor repair, and few men are comfortable in an all-female nursing class. In this theoretical framework, it would be extremely important for women and men considering careers in these traditionally "sex inappropriate" fields to have female mathematicians to serve as models for women and male nurses to serve as models for men.

The importance of same-sex role models was found in a study of college students who were taking a calculus class that is a prerequisite for majors in STEM disciplines (Stout, Dasgupta, Hunsinger, & McManus, 2010). The students either talked with a male or female STEM major, read biographies

about famous female and male scientists, or took classes with male or female professors. Across a variety of measures, female college students who were exposed to female experts in STEM disciplines identified more with STEM disciplines, reported that they felt more confident about their success in STEM classes, and were more likely to pursue careers in STEM disciplines, even though they still had negative stereotypes about women's success in STEM and continued to see these academic classes as masculine. The researchers reported that exposure to female experts served as an inoculation against the stereotype that "STEM is for men." Course grades were compared for male and female students in calculus to determine if having a male or female teacher affected course performance. If you are wondering whether the grades for female students actually improved under those conditions in which they were exposed to female experts, I hope that you can guess the outcome from what you have already read in several places in this book. The female college students had higher grades than the male college students in calculus, regardless of the sex of their professor (mean grade for the women was 9.25; mean grade for the men was 8.65, on a 10-point scale in which A = 10, B = 9, C = 8, D = 7). Recall that females get higher grades in school even in academic areas where they tend to score lower than males on standardized tests.

SOCIAL ECOLOGY

We suggest that children's peer interactions must be considered in light of their everyday social ecologies and that these ecologies at preschool are strongly organized by gender.

—Richard A. Fabes, Laura D. Hanish, and Carol Lynn Martin (2007, p. 205)

The social ecology perspective is a more recent conceptualization of the multitude of variables that influence the way we grow and the abilities we develop than the others considered in this chapter. The beginning premise for the theory of social ecology is that people's lives can only be understood by understanding the context in which they occur. Sometimes, social ecology is called "life review" because of the way proponents of this theoretical perspective view and review entire lives in terms of the social and historical periods—the context—in which they have lived. It is most often associated with the pioneering work of Uri Bronfenbrenner (Bronfenbrenner & Ceci, 1994), an influential developmental psychologist. Bronfenbrenner and his adherents view each individual as an active agent who contributes to his or her own development. They recognize the reciprocal ways in which life events change people and people, in turn, change their environment, thereby altering the trajectories of subsequent life events. In this sense, social ecology includes the idea that individuals actively make choices that influence the course of their lives, but it also recognizes the importance of biology in influencing the choices that people make. It differs

from a traditional interactionist view of heredity and environment in that social ecologists emphasize the way the environment unlocks the genetic potential of individuals; the way intellect unfolds in a particular context (Ceci & Hembrooke, 1995). Bronfenbrenner emphasized the larger social systems and how they can foster or inhibit the positive development of children. Friends, family, and children's and adolescents' own sense of self are important determinants of social, emotional, and cognitive development. An important component of this theoretical approach is recognition of the way social environments are constructed by and for children as they grow (Maccoby, 1995).

Development in Context

It makes sense that generations raised with different expectations and in different historical circumstances may age differently.

—Abigail J. Stewart and Joan M. Ostrove (1998, p. 1185)

The theoretical perspective of social ecology is predicated on the interplay among the characteristics of individuals, the social context in which they find themselves, developmental processes, and the way these components change over time (Moen, Elder, & Luscher, 1995). Human development depends upon the reciprocal influences of development and context. In infancy and during the toddler years, parents and family are the major contexts for child development. During this time of life, boys and girls are treated in very similar ways, with the only documented difference being that boys are treated more roughly during this period than girls are, and girls are talked to more about emotions than boys are (Kendall, 2007). But, in childhood, a new social structure emerges that is dependent on one's peers. It is a developmental period when children actively construct social structures that help to define middle childhood. It is at this developmental stage that boys' and girls' lives begin to differ in important ways. Children in middle childhood self-segregate by sex, with boys showing much more preoccupation with dominance and aggression. In adolescence, children begin the process of disengaging from their nuclear family, with girls kept much closer to the family than boys in societies that delay marriage beyond the adolescent years.

An important difference between the social ecology perspective and the others is its emphasis on historical events and the way in which one's age and sex determine the effect of an historical event on the individual. It assumes, for example, that the large numbers of women who entered the labor force en masse during World War II experienced a clash in the values they were brought up with as children and adolescents in the 1930s. Their younger siblings were also influenced by this historical event, but they were changed in different ways because they were at a different developmental stage at the time of the event. Certainly, we can see how this would be true for young men in the United States at the start of World War II. Many went to war and experienced

the horrific and sometimes heroic experiences of war, while their younger siblings, who were too young for war, and their older siblings, who were too old for war, watched from the physical safety of their homes. Being a young adult male during these years changed the life course for many of these young men compared to females of the same age and men of different ages at that time in history. Differences between those who went to war and those who stayed at home in areas that were not subject to fighting remain the same regardless of which war we are considering. Figures from the U.S. Department of Defense (2009) show that 86% of the people in the U.S. military (active duty) are men. It is important to keep this large figure in mind when thinking about sex differences in college enrollment rates and other important differences in the lives of millions of men and women. Thus, the importance of being male or female depends on one's age and on the historical context.

In applying the perspective of social ecology to the many questions about sex differences in cognitive abilities, it is assumed that individuals have multiple cognitive abilities and the potential to develop some or all of them in many ways. The abilities that get developed will depend on one's biological propensities, the context that is shared with the rest of society, the context that is altered by the individual, one's stage of development, and the sociohistorical context. Consider this contemporary example: Women now comprise a majority of all students enrolled in college, which is a major change over earlier enrollment patterns. The skills and abilities that large numbers of women are developing during the early decades of the 21st century are very different than those developed by the majority of women at the start of the 20th century. Similarly, the lives of men who go to war or have other sex-differentiated life experiences will determine how their cognitive abilities are developed and the subsequent course of their lives. Young men who go off to war because of historical events may develop certain physical or aiming skills that would not have been developed if they had gone to college or worked at a local factory instead. Similarly, advanced conceptual skills in abstract scientific thinking or the analysis of literature will probably not be developed, or their development will be delayed, for these hypothetical young soldiers.

COGNITIVE THEORIES

There is a large body of research that argues for the importance of gender schemas in guiding behavior.

—Harriet R. Tenenbaum and Campbell Leaper (2002, p. 615)

Cognitive theories are a general class of theories that are based on the primary importance of children's and adults' knowledge of sex-differentiated behaviors. They focus on children's active participation in learning gender roles and the way children construct knowledge about gender (which is not always

accurate). Kohlberg (1966) proposed a cognitive development theory to explain the acquisition of sex-typed behavior by children. A different sort of cognitive theory that explains sex role maintenance among adults is gender schema theory. An important theme in all cognitive theories of sex differences is the idea of “self-socialization,” which posits that children actively seek information about what it means to be a girl or boy and to understand what it means for them, personally (Martin & Ruble, 2009).

Cognitive Development Theory

Erin, a 4-year-old, explained to her aunt about a drawing she had done:
“The ones with eyelashes are girls; boys don’t have eyelashes.

—Carol Lynn Martin and Diane Ruble (2004, p. 67)

Kohlberg’s cognitive development theory begins with the general idea that children’s conceptions about the nature of the world change as they go through various developmental stages. Just as children’s understanding of number concepts changes at different ages, so does their understanding of sex roles and sex appropriate behaviors. Kohlberg believed that children went through three developmental stages: early gender labeling of the self and others occurred around 2½ to 3 years; a second stage involved understanding that gender remains stable over time; and finally the idea of gender constancy emerged, which is the idea that changing one’s appearance does not change one’s gender. Gender constancy develops around 4 to 6 years of age. Kohlberg argued that once children develop full understanding, they become particularly strongly motivated to model same-sex others.

In distinguishing the basic differences between social modeling or social learning theory and cognitive development theory, Kohlberg (1966) has said: “The social-learning syllogism is: ‘I want rewards, I am rewarded for doing boy things, therefore I want to be a boy.’ In contrast, a cognitive theory assumes this sequence: ‘I am a boy, therefore I want to do boy things, therefore the opportunity to do boy things (and to gain approval for doing them) is rewarding” (p. 89). The basic difference between these two theories is that social modeling assumes that children conform to sex role stereotypes and acquire a sex role identity because they imitate sex role consistent behaviors which are reinforced; whereas cognitive development theory assumes that children first develop an awareness of sex categories, then they form a sexual identity as part of their self-concept (I am a girl or I am a boy). After a sexual identity is formed, they engage in sex role consistent behaviors which get rewarded. Children do not begin to value sex appropriate behaviors and values until after they understand that being either a female or male is a permanent part of one’s identity that will never change.

There is good evidence that gender-related cognitions influence what young children think, do, and remember. In one study, young children were given novel toys and activities and they were told either “I think that boys like this

toy better than girls” or something more subtle about the appropriateness of a toy or activity for a girl or boy, such as: “This is a test to see how good you would be at mechanics” (Martin & Ruble, 2004, p. 69). The children had better memory for the sex appropriate toys and activities; they also expect to be more successful with them, and they actually were better with them than the toys and activities that were described as more appropriate for the other sex.

Gender Schema Theory

The term “schema” comes from cognitive psychology, the branch of psychology concerned with how we think, learn, and remember. It was applied to gender in two similar approaches that were proposed at about the same time. Bem (1981) proposed that our knowledge about sex differences forms a “schema” or an organizing framework in which we process, interpret, and organize information. In Bem’s discussions of gender schema theory, she focused on individual differences, and more specifically what happens to individuals with a strongly salient gender theory. A related theory of gender schemas was proposed by Martin and her colleagues (Martin & Halverson, 1983; Martin & Little, 1990), who focused their theory on children’s gender schemas. The notion of a schema is very close to what we mean when we talk about stereotypes. It refers to the way we store information in memory and utilize that information. Hyde (1985) describes it this way: “A schema is a general knowledge framework that a person has about a particular topic. A schema organizes and guides perception” (p. 76).

Gender schemas are “a set of ideas that define as appropriate for men and women particular skills, preferences, personalities and self-concepts, and that act as filters shaping our perceptions and interpretations of events” (Goodnow, 1985, p. 19). The categories of female and male form a framework that allows children to organize and interpret information about sex roles. Gender is an important and salient category that can be classified and used in understanding the world, so children actively use gender-related information in creating meaning and in determining their behaviors (Martin, Ruble, & Szkrybalo, 2002). Gender schema theory assumes that children learn to recognize their own sex and that of others, and they use this basic information about female or male groups to create gender schemas about what is appropriate for each sex and to determine what is appropriate for them. (“This is a toy for girls, and I am a girl, therefore I will probably like this toy” and “this is a course that is “for boys” and since I’m a girl, I’ll probably not do well in this course”). Martin and Halverson described the way gender schemas act to promote gender-typed behavior because children are motivated to act in ways that are consistent with their beliefs. Children use category information to draw inferences when they do not have direct knowledge. For example, as Martin et al. (2002) explained, when children were told about a girl who had “estro in her blood” (“estro is a “nonsense” term used in this study) the children reason that it is a quality of other girls and not of boys.

More recent studies of gender schema theory acknowledge that they are multidimensional rather than a single coherent set of beliefs (Tenenbaum & Leaper, 2002). Gender schemas can also explain inaccuracies in children's beliefs about boys and girls because children will distort information to make it fit their schemas. Distortions in memory are especially important because information is often misremembered in ways that support and confirm a stereotype.

When we interact with people, we use our schemas first to understand and then to remember what transpired. In a recent study, children aged 3 to 8 years were asked to draw a picture of a girl and a boy and to explain what made each picture a girl or a boy (Tenenbaum, Hill, Joseph, & Roche, 2010). In general, the children provided more reasons that were judged to be conventional (ones that most adults would agree upon, such as girls tend to have long hair) than unconventional reasons ("boys wear glasses with eyebrows" p. 143), with a developmental increase in conventional reasons. At the youngest ages (3 and 4 years old), the children had idiosyncratic views of what made someone a girl or boy. The authors concluded that conventional gender schemas develop gradually during early childhood. A typical response to the instructions to draw a girl or boy is shown in [Figure 7.2](#).

Children can demonstrate their knowledge about what is appropriate for each sex by the labels they use when referring to people. Children know and use gender labels (e.g., boy, woman) at around 18 months of age, with girls

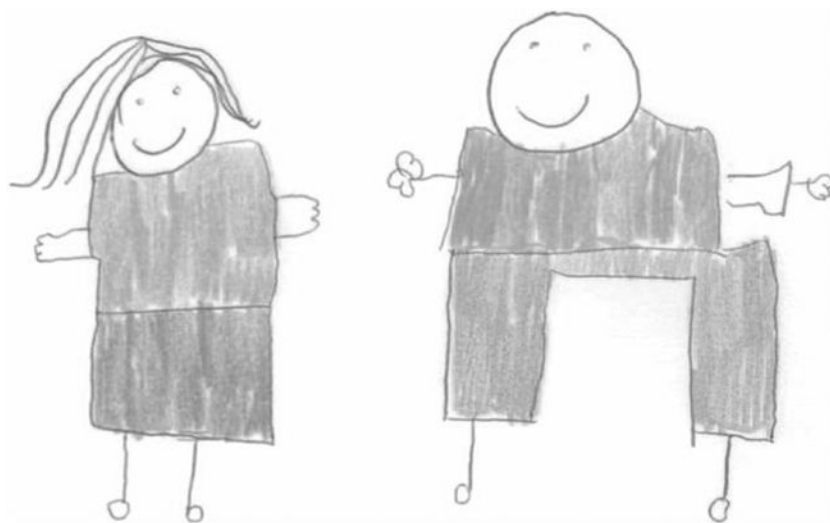


Figure 7.2 Typical response from children who are asked to draw a girl or draw a boy. From Tenenbaum, Hill, Joseph, and Roche (2010). © The British Psychological Society. Reprinted with permission from Wiley-Blackwell.

using these labels about one month earlier than boys do (Zosuls, Ruble, Tamis-LeMonda, Shrout, Bornstein, & Greulich, 2009). Children who knew and used gender labels exhibited more gender-typical play with toys, suggesting that there are consequences for behavior that come from the ability to use gender labels. Beginning in preschool and continuing through fourth or fifth grade, boys are seen as having short hair, playing more active games, and being rough; whereas, girls are seen as nice, wearing dresses, and liking dolls (Miller, Lurye, Zosuls, & Ruble, 2009). As explained in [Chapter 6](#), stereotypes are often accurate at the group level, and it seems that young children are able to infer group characteristics.

The Consistency of Sex-Typed Behavior

Those children who were the most sex-typed at age 2.5 were still the most sex-typed at age 5, with those children who showed the highest levels of sex-typed behavior during the preschool years continuing to do so at age 8.
—Susan Golombok, John Rust, Karyofyllis Zervoulis, Tim Croudace, Jean Golding, and Melissa Hines (2008, p. 1583)

One problem with all social learning theories is that sex-typed behavior emerges at a very young age. Boy and girl infants as young as 1 year show sex-typed preferences for different types of toys and by 3 years of age, girls are much more likely than boys to play with dolls, doll houses, and tea sets, and boys are much more likely than girls to play with toy guns, swords, cars, trains, and trucks (reviewed in Golombok et al., 2008). Of course, although it is possible that sex-differentiated preferences at 1 year reflect learning and experience, the very young age at which these preferences appear and the consistency of toy preferences make learning explanations more difficult to accept. By age 3, most children prefer to play with same-sex peers, and gender segregation is more likely to occur when adults are not present, again suggesting that these early sex-typed behaviors are less likely to reflect early learning. But, despite the well-known differences in the play preferences of young children, little has been known about the development of these preferences throughout childhood. To study this question, experimenters collected data from the parents of over 2,700 boys and 2,700 girls when their children were 2.5 years, 3.5 years, and 5 years old (Golombok et al., 2008). When the children were 8 years old, they provided their own data. The data from this U.K. sample showed that sex-typed behavior increased throughout these childhood years, and that later sex-typed behavior correlated with sex-typed behavior at younger ages. In other words, the children remain fairly consistent in their sex-typed behavior, with most children showing more sex-typed behavior at the older ages of childhood. In addition, girls showed a greater increase in sex-typed behavior over time than the boys did.



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ROLES OF EXPECTANCY-VALUES-MOTIVES IN ACHIEVEMENT MOTIVATION

The superwomen are weary; . . . In the 80's American women learned that "having it all" meant doing it all.

—Wallis (December 4, 1989, p. 80)

The most comprehensive theoretical model designed to explain sex differences in academic achievement was proposed by Eccles (Parsons) et al. (1983) and more recently by Eccles (1994; 2007) and Wigfield and Eccles (1992). It is a variation of a more general model called an expectancy $\times$ (times) value model. The underlying idea is that the outcome of a cognitive task will depend on how much the individual doing the task expects to succeed or fail and how much she or he values the outcome. Note that this model is expressed as a mathematical equation where the relationship between expectancy and value is multiplicative. Thus, if either the expectancy of success or the value of the outcome is 0, then, regardless of what the other variable is, together they are mathematically equal to 0. If a task has no value to an individual (it is mathematically equal to 0 in value) or if an individual believes that he or she has no chance of success (expectancy of success is mathematically equal to 0), then the multiplicative relationship is 0. Similarly, if both expectancy and value are high, their multiplied combination will be high, and if both are low, their multiplied combination will also be low.

Models of this type are really models of achievement motivation, and thus have a broad research literature that addresses many questions in addition to those about sex differences. They can be used to understand the capabilities and behaviors that are involved in situations where people are evaluated, situations like college entrance examinations, tests in school, and performance on cognitive tasks where someone will be grading the performance on the task. The underlying idea is that individuals persist at tasks in which they *expect* success and avoid tasks in which they *expect* failure. Similarly, individuals

persist at tasks when they *value* the goal and avoid tasks when they do not *value* the goal. Thus, expectations and values combine in ways that more or less motivate individuals to achieve at a task.

Recall from [Chapter 6](#) that, in general, women tend to place less value on tasks that involve working with “things” and more value on working with “people” (Su, Rounds, & Armstrong, 2009). Eccles (2007) found that the biggest predictor of whether women select career paths that lead to jobs in STEM fields is the value that they place on wanting to work in occupations where they can help people. This finding is not true for men, who place greater value on working with “things.” Thus, Eccles concluded that women often believe that they are able to succeed in occupations where they are traditionally underrepresented, but they do not want to work in these fields, even if they can be successful.

The actual model used to predict career choices is somewhat more complicated than simple measures of expectancy and values. We all make life choices based on a multitude of contextual variables, which include the cultural milieu, aptitudes, socialized beliefs, previous achievement, memories for events, goals, and other variables that are depicted in [Figure 7.3](#). Dozens of studies have supported the various links shown in this model (e.g., Eccles, Vida, & Barber, 2004; Fredricks & Eccles, 2002). Although I note here that this model has also been criticized for not incorporating actual measures of abilities.

Self-Efficacy

Self-efficacy is a classic theory in the psychological literature on motivation (Bandura, 1986). It explains the origins and operation of self-confidence, the belief that we can achieve a goal. The belief that an individual can or cannot achieve a particular goal may not be related to actual ability, but it is likely to have an effect on whether or not the goal is actually achieved. In general, people are willing to put more effort and resources into attempts to achieve a goal if they believe that they will ultimately be successful. Self-efficacy is a core belief in the ability to achieve a desired outcome from an action. It is essentially a cognitive theory in that beliefs about one’s ability are seen as the core that will determine the actions an individual is willing to take to reach a goal. The underlying idea of self-efficacy is that people’s beliefs about their ability to achieve a goal will influence their actual ability to achieve that goal because they will work harder and longer, and the increase in effort will improve their ability to achieve the goal. Self-efficacy is reflected in the expectancy component of the expectancy-values-motives model. This chain of events is depicted in [Figure 7.4](#).

The underlying idea in the concept of self-efficacy is that an individual’s beliefs about his or her academic abilities will determine what that individual does when faced with learning or performance tasks that utilize the abilities. For example, consider a study of third, fourth, and fifth grade girls and boys

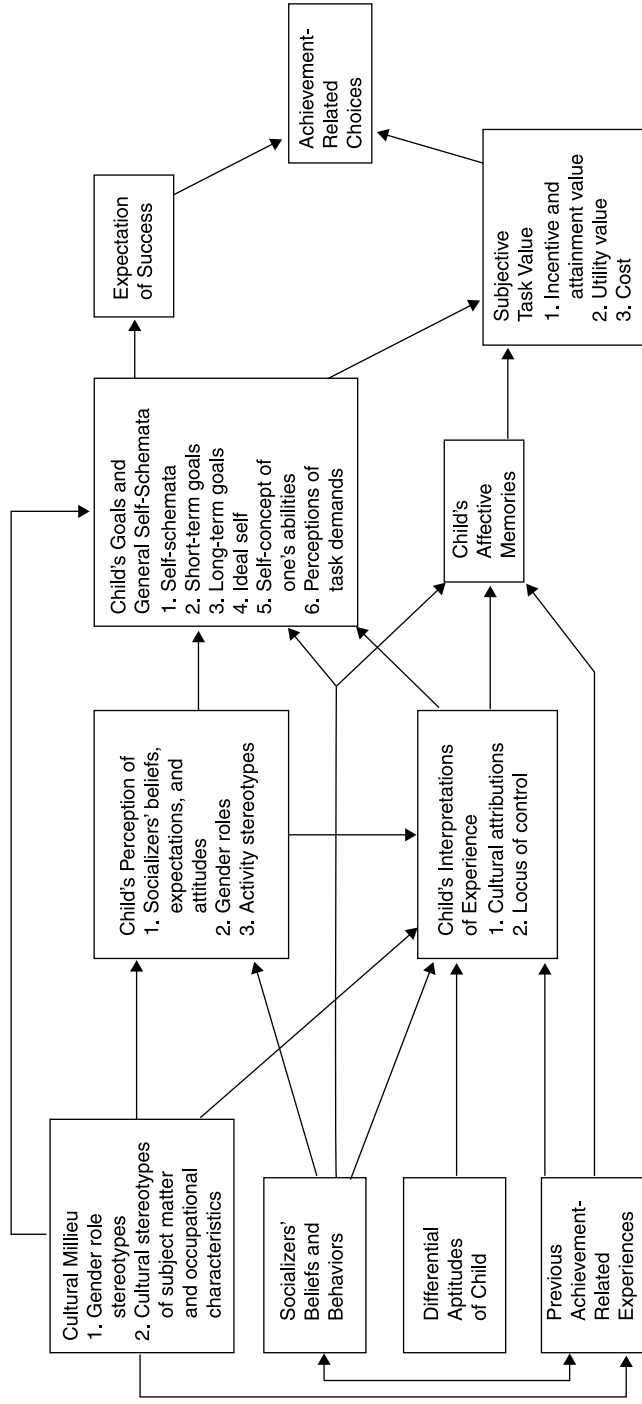


Figure 7.3 Model devised to explain how an interdependent network of values and expectations influence academic and career choices. From Eccles (1987). Reprinted with permission. Copyright © Blackwell Publishing. Reprinted with permission of Wiley-Blackwell.

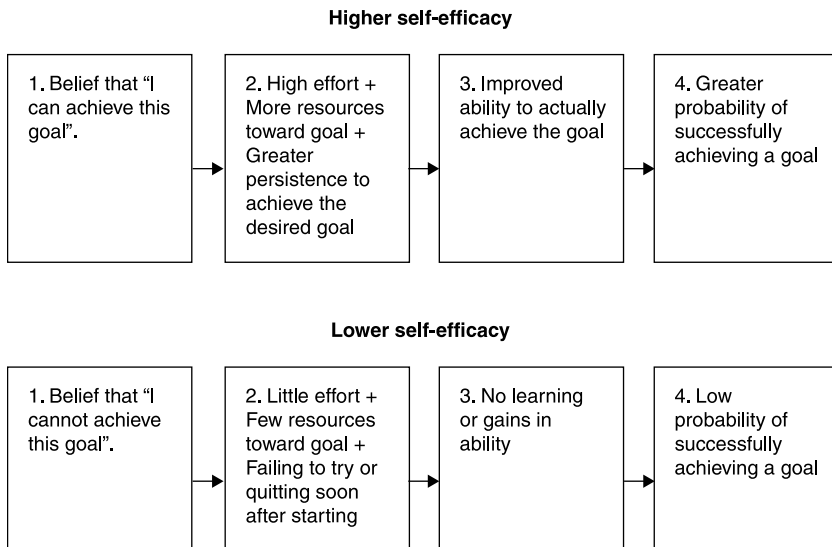


Figure 7.4 Self-efficacy model of achievement success. Individuals with high self-efficacy believe that they can achieve a goal and because of this belief they act in ways that enhance their ability to achieve the goal (e.g., hard work and persistence). Individuals with low self-efficacy do not believe that they can achieve a goal and therefore expend little or no effort, sometimes quitting soon after an initial attempt. These individuals do not improve in their goal-related abilities and have a low probability of success.

(Pajares, Miller, & Johnson, 1999). In this study each child's writing ability was assessed by the teacher, and a writing sample was rated by judges. The children in each grade also responded to questions about their writing abilities. There was a high degree of consistency in the results: The teachers judged the girls to be better writers than the boys, and the judges who rated the writing samples agreed that the girls were better writers than the boys. When the children answered questions about their own writing ability relative to other children, the girls, overall, rated themselves to be better writers than the boys rated themselves. Thus, all three groups—teachers, raters, and children—agreed that the girls were better at writing than the boys. The authors of this study discuss how these beliefs can have long-lasting effects, which are especially important when the children face obstacles in their writing. The authors use the concept of self efficacy to explain why children with similar ability levels often have widely differing levels of achievement.

A more recent study conducted with teens in the Netherlands also demonstrates how self-efficacy works in determining academic success (Vrugt, Oort,

& Waardenburg, 2009). It is interesting to note that these researchers found that the girls had much higher course grades in Dutch (the language spoken in the Netherlands) than the boys did ($d = 0.55$), and although there were no statistically significant differences between the girls and boys in their grades in mathematics, the boys scored higher on self-efficacy ($d = 0.44$) and on liking of mathematics ($d = 0.42$). They found that Dutch was more important for girls and mathematics was more important for boys, a finding that they interpreted as indicating the gender appropriateness of each subject. The researchers found that for both girls and boys, achievement in mathematics and Dutch depended on the individual's self-efficacy (beliefs that they can succeed), and social comparisons (their ability relative to others), which together predicted how much they liked each subject and their likelihood of being successful in each subject. This model also suggests that if we can make children feel better about their abilities to succeed, we can improve performance for both boys and girls in math and science.

Models of Academic Achievement

How does the idea that values and the expectancy of success are important determinants of success at any task apply more generally to cognitive sex differences? Consider some of the ways values and expectancies could be operating to depress female achievement in advanced mathematics. The same sort of determination could be made for the other cognitive abilities that are presented in this text, but it is easiest to apply this model to achievement in mathematics because there is a large research and theoretical literature that pertains to sex differences in advanced mathematics.

Benbow (1988) listed many of the psychosocial hypotheses that have appeared in the literature to explain sex differences in mathematics. I summarize, embellish on, and borrow from her listing. Interested readers will want to consult Benbow's paper along with the many responses to it. There are approximately 500 references related to studies in mathematics that the author and commentators used to support their points and to refute those that they did not agree with and the literature has grown exponentially since this article first appeared. I will keep this section relatively brief because those of you who want to delve into the topic further can consult this excellent article with its related commentaries and rebuttal.

- 1 *Females maintain more negative attitudes toward mathematics.* As with every area of research, the literature is not entirely consistent in reporting these findings, but the vast majority of times when differences are found they are in the predicted direction with females more negative than males. (See, for example, Hyde, Fennema, Ryan, Frost, & Hopp, 1990 and the recent article from the Netherlands just discussed, Vrugt, Oort, & Waardenburg, 2009.) This is an interesting result given that women are

now close to 50% of the undergraduate mathematics majors in the United States (National Science Foundation, 2007).

- 2 *Females perceive mathematics to be less important for career goals than males do.* Again, while there are some failures to confirm this hypothesis (e.g., Singer & Stake, 1986), when differences are found, they tend to support this contention. Recent research has concluded that although girls now feel competent in mathematics, they are less likely than boys to find it intrinsically interesting (Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005). This is important because it relates directly to motivation. At least some of the time, most students will have to exert time and effort to comprehend advanced mathematical concepts. If females, in general, believe that mathematics is less useful to their future careers, then they are less likely to exert much effort to learn the concepts. The finding that fewer women than men actually have careers in many math-intensive fields supports this idea, but recall that the majority of accountants are female, so perhaps this idea is fading. In general, girls demonstrate different occupational interests, and as discussed earlier, are more interested in people than things (Su et al., 2009). This belief is sometimes seen in the popular media. I remember sitting in a movie theater several years ago watching the movie *Peggy Sue Got Married*. In this fantasy film, a grown woman has the opportunity to return to high school with the knowledge and experience she had accumulated in her adult life. In her mathematics class, she assures her teacher that she will never need to know the mathematics he wants her to learn. A spontaneous cheer went up from the movie audience, many of whom seemed to agree with her pronouncement about the uselessness of mathematics for women's lives.
- 3 *Females have less confidence in their ability to learn mathematics.* This is an interesting hypothesis because, although females expect to receive lower course grades in mathematics than males do, females, in fact, receive the higher course grades even in advanced mathematics courses (Willingham & Cole, 1997). Beginning in third grade, girls rated their competency in mathematics lower than boys did, even though there were no sex differences in achievement (Herbert & Stipek, 2005). Although females may be less confident, they are performing better in virtually all mathematics courses. Females are also more likely to attribute success in mathematics to effort than to ability (Ryckman & Peckham, 1987). Even women who enter college majors in math-intensive fields and are as qualified as their male peers experience a drop in confidence during their first year of study (Brainard & Carlin, 2001). Pajares (2005, p. 304) summarized the research literature on math self-efficacy: "Most researchers found that male students report stronger mathematics self-efficacy beliefs than do female students, although it bears emphasizing that a number of researchers have failed to find differences."
- 4 *Mathematics is a male-stereotyped cognitive domain.* There are three components to this belief. First, there are more males in advanced

mathematics courses in college, but the number of female and male mathematics majors is now close to parity; larger differences favoring males are found at the postgraduate level. Second, mathematics is stereotyped as a male domain, despite the near equity in undergraduate majors, so the stereotype persists despite the fact that actual differences in enrollment patterns have narrowed. Third, females may be discouraged by the male stereotyping of mathematics. Adolescents endorse more sex-typed occupational interests, with higher preferences for those occupations in which the majority is their own sex (Turner & Lapan, 2004). If you doubt this, show a few friends [Figure 7.5](#), which is an artist's rendition of the stereotypical female mathematician. Ask your friends to guess the college major of the woman depicted. The stereotype that females who succeed in mathematics and the sciences are masculine can be vicious and demeaning. Again, I will provide a personal example that brought this fact home to me in a much more vivid manner than any of the research that I have read. A male college student was showing me around UCLA's very large campus.

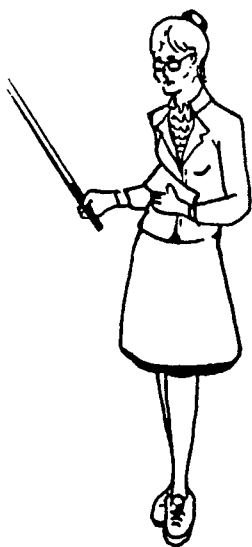


Figure 7.5 An artist's conception of the stereotypical "woman mathematician" as described by Professor Martha Smith: "Many people on hearing the words 'female mathematician' conjure up an image of a six-foot, gray-haired, tweed suited oxford clad woman.... This image, of course, doesn't attract the young woman who is continually being bombarded with messages, direct and indirect, to be beautiful, 'feminine' and catch a man" (cited in Ernest, 1976, p. 14).

We went to the portion of the campus that houses the engineering school, mathematics, and physical sciences departments. He told me that there is a derogatory name for the female students on that part of campus ("science dog"). The message was quite strong that being an attractive female and studying mathematics and the sciences are not compatible. This ugly moniker saddened and angered me. Name-calling designed specifically to denigrate females who study mathematics and the sciences provides strong support for the notion that mathematics is a male-stereotyped domain.

- 5 *Females receive less encouragement and support for studying advanced mathematics.* In a survey of the parents of junior high school students, Yee and Eccles (1988) found that parents believe that mathematics is more difficult for their daughters than for their sons. These beliefs would presumably translate into giving their daughters less support for studying advanced mathematics than their sons. More recent studies have found that parents provide more math-supportive environments for their sons than their daughters by purchasing more math/science toys for them, spending more time on math/science activities with their sons, and maintaining higher perceptions of their sons' math abilities than their daughters (Jacobs et al., 2005). Other researchers found differences in the explanations used when mothers talked to their daughters and sons about science-related topics, with more attempts to generate hypotheses about a science task—playing with magnets—when talking with their sons (Tenenbaum, Snow, Roach, & Kurland, 2005). Thus, differences in encouragement may be subtle, but when they are found, they tend to support the idea that boys receive more encouragement in science and math.
- 6 *Females take fewer mathematics courses than males; therefore, they score lower on tests of mathematical reasoning ability.* This is a prediction that is now only true at the graduate level. In high school, the number of males and females who take calculus is approximately equal (U.S. Department of Education, 2007b). Women earn nearly half of all bachelor's degrees in mathematics, but only 27% of the doctoral degrees (National Science Foundation, 2007). But there have been studies that have controlled for number of mathematics courses taken, and sex differences are still found favoring males (e.g., Gallagher, 1998; Willingham & Cole, 1997).

Even if some of these hypothesized reasons to explain sex differences in advanced mathematics are weak or even wrong, the effect of socialization on females and males comes from the totality of experiences and not any one of them in isolation. It seems intuitively obvious that these are important variables in understanding success in mathematics. Few people would persist in higher mathematics coursework if they believed that they did not have the ability to learn the material, if they felt that it was of little value, or if they were routinely discouraged by their parents and teachers.

BENT TWIGS

Tis education forms the common mind.

Just as the twig is bent, the tree's inclined.

—Alexander Pope (quoted in Bartlett, 1980, p. 335)

Sherman (1967) proposed a theory to explain female superiority in language memory and usage. It has come to be known as the “bent twig hypothesis” in reference to an old saying that goes something like this, “as the twig is bent, so the tree shall grow.” Sherman began with the assumption that girls talk at an earlier age than boys. The reasons why girls talk at an earlier age are not as important as the consequence. Because of their early advantage with language, girls rely more on verbally and socially mediated approaches in their interactions with people and objects in their world. Boys, on the other hand, rely upon their better developed musculature to interact with people and objects; thus, they move about more, a fact that could contribute to the development of their spatial skills. Each sex develops somewhat fixed patterns or preferences for interacting, with the result that early developmental differences guide later actions. In this way, a small initial difference in abilities between the sexes grows larger over time. It is interesting to note that the bent twig hypothesis does not explain the initial sex differences with respect to verbal, motor, or other abilities. It could be due to early differential reinforcement patterns for infant vocalizations, or due to biologically based readiness to produce language, or some interaction of these two possibilities.

Biological Propensities and Beneficial Environments

Casey and her colleagues (Casey, 1996; Casey, Nuttall, Pezaris, & Benbow, 1995; Pezaris & Casey, 1991) developed a program of research that explored the way biological predispositions, especially small ones, can interact with social influences, like parental encouragement, to create fairly large sex differences in cognitive abilities. She identified girls with biological correlates of mathematical giftedness. (Recall from [Chapters 4 and 5](#) that left-handedness is statistically associated with high levels of math achievement.) If these girls also had mothers who encouraged non-sex-typed behaviors, the biologically talented girls were more likely to achieve at the highest levels of mathematics than girls who did not have this combination of biological and environmental factors. Casey describes her research approach as an example of the bent twig hypothesis because initial differences in abilities, which arise from the biological basis of sex differences, are then magnified by differential experiences.

In another study that typifies the “bent twig” approach, Casey, Nuttall, and Pezaris (1997) examined the way confidence in one’s ability to succeed in math and math anxiety relates to performance on the SAT-M for a sample of

high-performing adolescents. These measures are in the tradition of the self-efficacy and achievement motivation literature because they assess expectations of success at math tasks. In addition, Casey et al. obtained measures of the visuospatial abilities (i.e., a mental rotation test like the one described in [Chapter 3](#)) of their participants because visuospatial ability has already been established as a moderator in the differences between males and females on the SAT-M (Casey, Nuttall, Pezaris, & Benbow, 1995). These investigators controlled for a variety of other variables that might affect the results, such as the number and type of mathematics courses that the participants had taken. The investigators found clear evidence that visuospatial skills are important in SAT-M scores, perhaps because the participants who scored well on the SAT-M used visuospatial strategies to solve problems. Furthermore, they found that confidence in one's ability to solve math problems was also an important factor in determining SAT-M scores, although it was not as important as visuospatial ability. Thus, visuospatial ability and self confidence are *both* involved in determining SAT-M scores. What is particularly appealing about this approach to studying sex differences in cognitive abilities is that it includes a variety of different sorts of measures and looks both to abilities and beliefs to provide an explanation of complex phenomena.

Sex Differences in Self-Discipline

Women typically earn higher grades than predicted by their performance on ability or achievement tests, and men earn lower than expected grades.

—Angela Lee Duckworth, and Martin E. P. Seligman (2006, p. 198)

The more one understands the way males and females are sometimes different and sometimes the same on different cognitive measures, the messier the entire field of cognitive sex differences becomes. The finding that girls get better grades in school and boys score higher on many standardized exams, especially those that are not closely tied to what is learned in school, poses many problems (Pomerantz, Altermatt, & Saxon, 2002). How can we understand these discrepancies in performance? Duckworth and Seligman (2006) believe that the answer lies in girls' greater self-discipline.

Concepts like stereotype threat or sex role stereotyping cannot explain why girls, for example, get higher grades in math and science *and* lower scores on standardized examinations. Of course, the biological theories also come up short in trying to explain these disparate findings. Duckworth and Seligman defined self-discipline as being able to suppress a response in order to achieve a higher goal. They maintain that self-discipline requires conscious effort. Examples of self-discipline include not losing one's temper when angry, reading instructions before beginning a test, paying attention in class instead of day dreaming, and doing homework instead of watching television. To test the hypothesis that girls are more self-disciplined than boys, the researchers created

a self-discipline scale appropriate for eighth grade students. In addition, the children responded to a series of questions that assessed self-discipline such as “Would you prefer \$55 today or \$75 in 61 days?” The ability to delay gratification was used as a measure of self-discipline. The scale was made up of several questions about the extent to which the children inhibited their initial responses and delayed rewards. Both the measure completed by their parents and the one completed by the children showed the expected outcomes. In a sample of 140 students, the girls were rated by their parents as having more self-discipline than the boys were. The girls achieved higher grades in algebra, English, and social studies. In fact, sex differences in self-discipline were predictive of sex differences in grades—students who had the most self-discipline tended to have the highest grades. The authors replicated this general study and concluded that girls’ greater self-discipline gives them the edge in grades.

The Problem With Multiple Talents—Cognitive Tilt

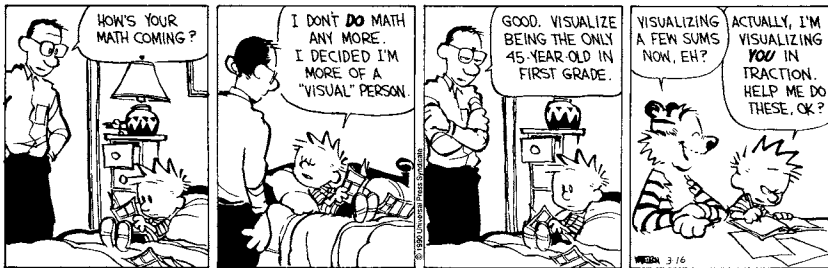
Ability tilt contributes to the prediction of the domain in which exceptional accomplishments are likely to occur.

—Gregory Park, David Lubinski, and Camilla P. Benbow (2007, p. 951)

How do people make decisions about what sorts of studies to pursue? In a series of studies of intellectually elite youth, Lubinski and Benbow and their multiple colleagues have asked this question (Park, Lubinski, & Benbow, 2007). Most people could succeed at many different careers, but they can only select one (or one at a time). What about people who are gifted in multiple areas? Why do more women decide to pursue careers in the arts and in helping professions and more men decide to pursue STEM careers? Their studies began with gifted students who scored at least 390 on the math portion of the SAT test when they were 13 years old, which put them at the top 1% of their age class. For more than 20 years, the researchers followed cohorts of more than 100,000 teenagers who were identified as intellectually precocious when they were 13 years old.

The researchers calculated a “tilt score” for each participant. This score was calculated by subtracting each person’s SAT-V score from their SAT-M score. Thus, a tilt score of 0 indicated that they scored the same on both the verbal and math portions of the SATs at age 13; a positive score indicated that the SAT-M was higher, and a negative score indicated the SAT-V was higher. The researchers found that, in general, the talented girls in their sample had a broader range of abilities than the talented boys did—in other words the girls’ scores tended to be closer to 0; whereas the boys tended to score considerably higher in math ($d = 0.72$).

It turned out that having a “quantitative tilt” was an important factor in determining how the participants thought about their abilities. Most of the girls



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had very high math scores, but their verbal scores were also likely to be high, so they tended to think of themselves as being better in verbal areas, even when they matched some of the highest scores in math. For boys, the mismatch between verbal and math scores could be seen in many measures. For example, 64% of the boys said their favorite high-school class was in math or science, while only 39% of the girls identified math or science as their favorite subject. Even among this elite group of gifted students, the women who went into the sciences were more likely to major in life sciences (i.e., biology) than the physical sciences, and they entered careers in the humanities at higher rates than the mathematically gifted boys.

These studies reveal two important points: (1) SATs administered to preteen girls and boys were predictive of future college majors, areas of interest, and career choices; and (2) People tend to think of themselves as either “math and science” people or “language and humanities” people. To determine which type of person they are, most people will compare their abilities in these broad areas and identify with the one in which they achieve higher scores. Thus, even though the women in the studies of precocious youth could have been highly successful in mathematics and science, many decided that they had an even greater advantage in other fields. This is another example of the way initial small differences in achievement can lead to major differences in career choices.

CULTURE COUNTS: SURPRISING AND CONTRADICTIONARY EFFECTS OF GENDER EQUITY

In more gender-equal societies, girls perform as well as boys in mathematics and much better than them in reading.

—Luigi Guiso, Ferdinando Monte, Paola Sapienza, and Luigi Zingales
(2008, p. 1165)

International studies of cognitive sex differences show both similarities and differences. A close examination of the cross-national differences shows that how likely any person is to succeed in any academic domain is strongly determined by where they live. But the effect of culture is complex and it may not always operate in ways that we would predict.

Gender Equity Reduces the Male Advantage in Math and Increases the Female Advantage in Reading

In one study, researchers examined the test scores of boys and girls using data from the Programme for International Student Assessment (PISA; Guiso et al., 2008). The database for this assessment contains information from over 276,000 students, 15 years of age, from more than 40 different countries. Worldwide, boys outscored girls in math (scoring about 2% higher, which was equal to 10.5 points on the test), and girls outscored boys in reading (scoring about 6.6% higher, which was equal to 32.7 points on the test). Girls scored higher than boys in reading in all of the countries for which they had data. But the researchers looked beyond the worldwide averages and examined how countries differ in both the size and direction of sex differences in mathematics. The sex differences in mathematics and reading for each country are shown in [Figure 7.6](#). Values above 0 indicate an advantage for girls; values below 0 indicate an advantage for boys

The authors of this cross-national study of mathematics and reading classified countries according to several measures of gender equality, using indices such as the World Economic Forum's Gender Gap Index and measures taken from the World Values Survey. They calculated cultural attitudes toward gender equity by using the level of agreement with statements like, "When jobs are scarce, men should have more right to a job than women" (p. 1164). They found a correlation between gender equality and the gender gap (difference in male versus female scores) in mathematics, with countries with more egalitarian attitudes and practices showing the smallest gaps (in general). The relationship between the math gender gap and the emancipation of women is shown in [Figure 7.7](#). Notice that a math gap of 0 means that boys and girls scored about the same, negative values indicate an advantage for boys and positive values indicate an advantage for girls. There were three countries in which girls scored higher than boys in math: Iceland, Thailand, and Indonesia. In general, countries with low scores on the emancipation of women (e.g., Turkey, Korea, and Tunisia) tend to have larger gaps favoring males than countries with higher scores on the emancipation of women. It is interesting to note that even in gender-equal countries, girls tended to score higher in arithmetic than they did in geometry, which I assume reflects the much higher scores boys usually achieve on tests of visuospatial skills.

It seems likely that if a scale of gender equality showed a reduction in the mathematics gender gap as countries become more equal, then a similar effect

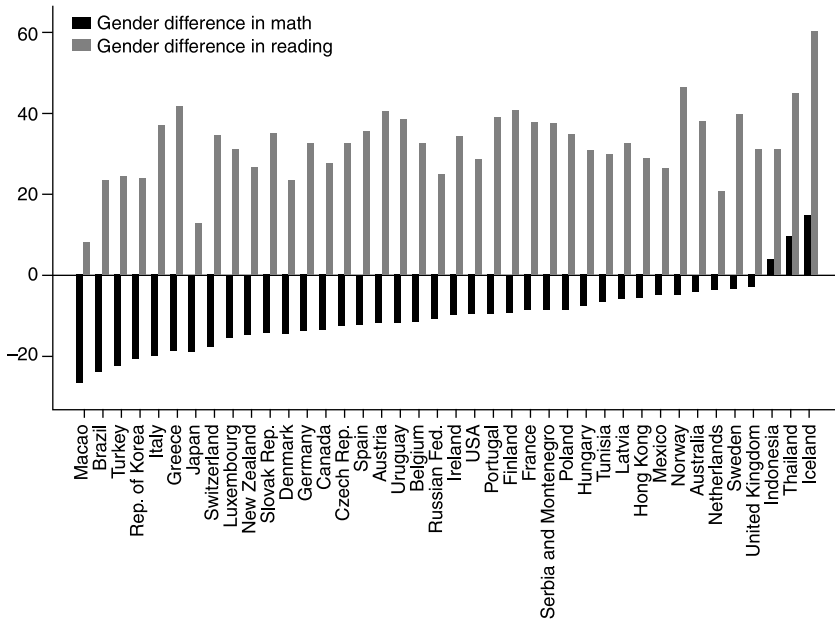


Figure 7.6 Differences in the scores of 15-year-old boys and girls in math and reading. Data calculated from the Programme for International Student Assessment (PISA) 2003. Figure from supplementary online materials for “Culture, gender, and math” by Guiso, Monte, Sapienza, and Zingales (2008). Reprinted with permission from AAAS.

might be found for the reading gap, which is larger than the math gap and favors girls. Surprisingly, the researchers found the opposite results. The reading gap favoring girls gets larger in more gender-equal countries. Thus, for more gender equal countries, girls gain on the boys in mathematics and enhance their lead in reading.

Hyde and Mertz (2009) found that there is little or no difference between girls and boys in the United States when their math abilities are assessed with the National Assessment of Educational Progress (NAEP). The NAEP is a federally managed program that samples students’ academic achievement each year. Even for the math problems rated as the most difficult on the NAEP, sex differences were so small they were categorized as “trivial” ($d = 0.07$). These results may seem surprising given the data just reviewed from the international test known as PISA that showed consistent sex differences favoring males in all but three countries. Recall that sex differences in mathematics tend to be small when the material is more closely aligned with what is taught in school, whereas it tends to be larger when the items are not matched to the curriculum. Thus, even though both measures are assessing mathematical performance,

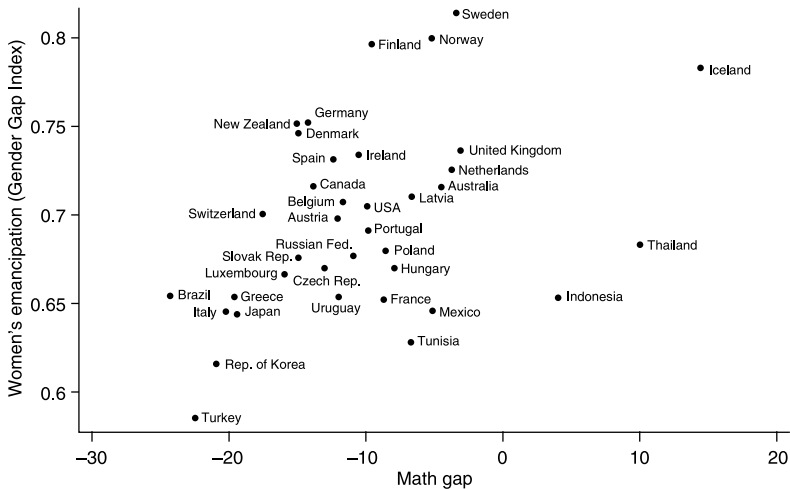


Figure 7.7 The correlation between scores on a scale of women's emancipation and the gender gap in mathematics ($r = .59$). Notice that in general, the gap is smaller in countries with high scores on women's emancipation. From Guiso, Monte, Sapeinza, and Zingales (2008). Reprinted with permission from AAAS.

they are assessing different aspects of mathematical performance—one is more closely aligned to what has been taught in school (NAEP) and the other is not tied to any curriculum and thus uses mathematics problems that may require a novel approach to obtain a solution (PISA).

Hyde and Mertz (2009) correlated the percentage of girls from each country who scored in the top 30 ranked teams in the International Mathematics Olympiad with each country's Gender Gap Index, which was calculated from a variety of measures in a way that was similar to the calculations used by Guiso et al. (2008). These data are shown in [Figure 7.8](#). Note that in this graph, high scores on the Gender Gap Index (more equal treatment of males and females) are positively correlated with the percentage of girls in the top 30 ranked teams in the International Mathematics Olympiad.

Another study of cross-national patterns of sex differences in math performance confirmed these findings with mathematics. Else-Quest, Hyde, and Linn (2010) examined patterns of sex differences using two international data sets—the 2003 Trends in Mathematics and Science Study (TIMSS) and the PISA, which was described above. They found that gender equity in school enrollment, women's participation in research occupations, and women's representation in parliament (or the main governing body) were the most powerful predictors of cross-national differences in mathematics, with the more equitable countries showing the smallest gaps (in general).

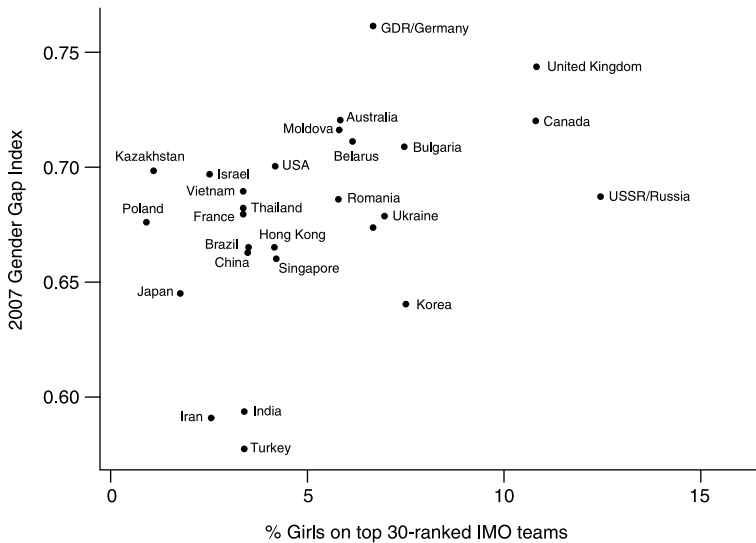


Figure 7.8 Presence of girls in top 30-ranked International Mathematics Olympiad (IMO) teams correlates strongly with each country's Gender Gap Index. From Hyde and Mertz (2009). Reprinted with permission from the National Academy of Sciences.

Gender Equity Increases the Male Advantage in Visuospatial Skills

Men's and women's mean levels of performance on the two visuospatial tasks were linked to social, cultural, and environmental factors.

—Richard A. Lippa, Marcia L. Collear, and Michael Peters (2010, p. 996)

The studies just reviewed all examined the effects of some measure of gender equality on test performance in mathematics or reading. Recall from [Chapter 3](#) that large-scale international studies have been conducted using data collected from a BBC internet site. One of those studies compared the performance of 111,000 men and 90,000 women on two tests of visuospatial skills—mental rotation and judgment of line orientation (Lippa, Collear, & Peters, 2010). In every one of the 53 nations used in their study, men outscored women on both visuospatial tests. Despite the consistency in the direction of the difference, there was considerable variability in the size of the difference between women and men across the globe. For example, sex differences were small in Pakistan, where overall scores were very low for both men and women, and thus the small difference between men and women on these visuospatial tests probably reflects a floor effect in this country. (Recall that the term “floor effect” means that

when both groups perform very poorly, it can be difficult to discern differences between the groups. Even though lower scores were possible, the results can still represent a floor effect.) The researchers who conducted this massive study wondered if sex differences on these two visuospatial tasks would vary as a function of gender equality across countries. They used indices from the United Nations and economic development data to construct a scale of gender equity that would allow cross-country comparisons. The results may surprise you. (They surprised me.) According to the authors: “Sex differences in both mental rotation and line angle judgment performance tended to be larger in gender egalitarian and economically developed nations than in less egalitarian and less developed nations” (p. 995). In other words, visuospatial sex differences are largest in the most gender equal countries, suggesting that the performance of both males and females was suppressed in countries with unequal gender norms.

Implicit Attitudes Regarding Women and Science Correlate With International Test Scores in Science and Mathematics

Nosek and his colleagues provided another piece of the puzzle of understanding achievement in science and mathematics (Nosek et al., 2009). Recall from [Chapter 6](#) that the IAT is a computerized test in which participants respond as quickly as possible about category membership for terms that are shown on the screen. In a science and gender test, participants are faster at associating male with science and female with liberal arts than the reverse. Nosek et al. used data from 34 countries to see if implicit stereotypes across countries correlated with math and science scores on the TIMSS, which is an international test of math and science. Using data from eighth graders in 2003, they found that the extent to which IAT scores showed that math was associated with being male correlated with the male math advantage on the TIMSS. This result is in agreement with the other international studies that found that the male math advantage disappears in more gender-equal countries, which presumably have fewer implicit attitudes about math being a male discipline. They found a similar relationship with science test scores for eighth graders on the TIMSS.

Making Sense of the Gender Equality Data

It is not uncommon for universally available interventions to actually widen preexisting gaps.

—Stephen J. Ceci and Paul B. Papierno (2005, p. 156)

Taken together, at least at the time of writing this book, the cross-national data on gender equity show that, as gender equity increases:

- the male advantage in mathematics virtually disappears
- the female advantage in reading grows larger
- the male advantage in visuospatial tasks grows larger
- countries with larger implicit attitudes that math is a male domain have larger differences favoring males for eighth graders on international math and science tests.

This combination of findings is counterintuitive because no simple theory can explain this pattern of results. In their discussion of the cross-national findings with two visuospatial tasks, Lippa, Collaer, and Peters (2010) review several possible theories. Theories related to sex role stereotyping might predict that more gender equality would lead to more equal performance between women and men across all cognitive tasks. This prediction would be based on the assumption that stereotypes would be strongest in those countries with the most inequality, and if cognitive sex differences were (largely) caused by the stereotypes about what is acceptable for men and women, then by reducing or eliminating them, cognitive sex differences would move close to zero. This was the pattern of results for mathematics, but not for reading or visuospatial skills. This cross-national pattern of results also does not conform to the predictions from stereotype threat or any theory about sex role learning or socialization. These results are also not easily explained with any of the biologically based theories either.

It is interesting to note that studies in other areas of psychology have also found an increase in sex differences in countries that are “prosperous, healthy, and egalitarian” (Schmitt, Realo, Voracek, & Allik, 2008, p. 168). In a study of personality traits across 55 different cultures, Schmitt et al. reported that sex differences were larger in those cultures in which women have opportunities that are more equal to those of men. Specifically, women scored higher than men on personality scales that measured neuroticism, agreeableness, extraversion, and conscientiousness and these differences were largest in the most egalitarian cultures. The authors of this study considered three possible theories for sex differences in personality, all of which have been proposed as theories of cognitive sex differences as well. They ruled out theories that claim that sex differences are byproducts of rigid sex roles because they found exactly the opposite data in their cross-cultural study. They also eliminated theories that claim that sex differences are an artifact of sloppy measurement or social desirability in how people respond because their data show clear, and for some, counterintuitive, results that are the opposite of social desirability in responding is operating.

One might expect to find the most socially desirable responding (saying what is expected for men and women regardless of what is true) in countries in which women have many fewer opportunities than men do, but the results are opposite to this expectation. Finally, they considered evolutionary explanations. According to evolutionary theory, sex differences would emerge only in

those domains in which the sexes faced different adaptive problems in evolution. So, for example, it might be expected that women would be more nurturing than men because women did most of the infant and child care. But even this explanation comes up short because there were wide variations across cultures, and evolutionary theories would predict more homogeneity across cultures. In short, they offered no solid explanation for their cross-cultural results.

How can we make sense of the findings about culture and cognitive sex differences? Although this explanation is speculative, recall that for most people (within the average range of abilities—not the extreme tails where the most and least gifted individuals are found), the size of the sex difference in mathematics tends to be small. The large difference on college admissions tests and graduate school tests may be due in part by the fact that individuals who take these tests are well beyond “average” when compared with the rest of the population. Thus, excluding the tails of the distributions, the sex difference in mathematics is small. When cultures encourage equal education and participation in the workforce for males and females, sex differences in mathematics disappear.

The sex differences in reading (favoring females) and in visuospatial tasks (favoring males) are much larger than those found in mathematics, and these differences in reading and visuospatial tasks tend to be larger in more gender equal countries. For a possible explanation I turn to a related literature on attempts to equalize achievement between other groups such as groups of children from different levels of socioeconomic status. Educational psychologists use the term the “Matthew effect,” which is borrowed from the Gospel idea that an initial advantage in any area leads to cumulative differences that widen preexisting gaps (Ceci & Papierno, 2005). If an intervention is designed to close the gap between any two groups, and it is available to everyone in both groups, then the gap inevitably widens. If instruction is somehow designed to maximize learning for both girls and boys, then in fact, any existing gap would be expected to widen, as both girls’ and boys’ achievement would be expected to improve. This phenomenon has been observed across a wide range of interventions designed to reduce the gap between groups of students. (See Ceci and Papierno, 2005, for a review of the literature.) If we think of countries where the education and cognitive enhancement of both sexes are encouraged, then the group with the higher level of achievement seems to benefit more than the group with the lower level of achievement.

We can think of these findings with reading and visuospatial tasks as ecologically valid (i.e., real-world) examples of the multiplier effect. Dickens and Flynn (2001) devised a mathematical model that can explain how events in the environment interact with heritability to produce large changes in cognitive abilities. In this model, the role of heritability need not be large. If girls show a slight advantage over boys (in general) in reading, then this small advantage will grow as parents buy girls more books, girls make even greater gain in reading proficiency, and thus come to enjoy reading, and then become more

likely to read as a leisure activity, and ultimately pursue careers in verbal fields. Visuospatial skills would be multiplied in a similar way for boys, who may show a slight initial advantage in visuospatial skills which are enhanced by doing puzzles, playing with blocks, tinker toys, and erector sets. As they grow, more boys play video games, and so on.

WORK-FAMILY CONFLICT: THE CAREGIVING DEMANDS OF ADULT LIFE

As described earlier, in 2005, Lawrence Summers, who was president of Harvard University at the time, offered his personal beliefs for why women are underrepresented in STEM fields, especially in faculty positions at research-intensive universities. He identified three broad hypotheses as possible explanations: (1) high-powered job hypothesis; (2) differential availability of aptitude at the high end; and (3) different socialization and patterns of discrimination in the faculty search process. His second hypothesis about too few women with high level ability was discussed in earlier chapters where data were presented showing that the proportion of males to females in the high ability tails of distributions has declined from 12 or 13 to 1 in the early 1980s to 3 or 4 to 1 (Wai, Cacchio, Putallaz, & Makel, 2010). Thus, although there are fewer women among the highest scorers on ability tests, the proportion of women has been rapidly increasing over the last several decades, and there certainly are many women with exceptionally high ability. Summers dismissed his third hypothesis about discrimination against women in STEM fields based on the reasoning that if some STEM departments discriminated against women, then the one or few that did not would have many outstanding women among their STEM faculty; since there were no such campuses, there could not have been discrimination against women in the hiring or promotion process. His hasty dismissal of all that is known about stereotyping, social expectations, and in-group out-group behavior created a firestorm of controversy. He later retracted his statements and pledged \$50 million to enhance faculty diversity and support women's programs at Harvard.

High-Powered Job Hypothesis

Summers' "high-powered job" hypothesis has considerable merit. It considers the larger context of men's and women's lives, especially their family lives. Higher education is one of the few places that has an early "up or out" system for retention and promotion. Law and accounting firms that require early partnership are the only other comparable models where young talented employees must prove themselves in the first six or seven years of their careers. For a scientist, who will usually have a postdoctoral position after receiving a doctorate, tenure decisions will be made around age 36 (at the earliest), which

means that tenure clocks run in the same time zone as biological clocks. A study of the age at which women in academia have their babies showed interesting results. Researchers found that early babies—having a baby before achieving tenure—hurt women’s careers in academia but help men’s (Mason & Goulden, 2004). Women who want a career in academic science will have to make greater sacrifices than men, because in general, women have greater care responsibilities than men do. The inflexibility of the tenure system to accommodate to the reality of women’s lives is the more likely and proximal cause of the underrepresentation of women in academic science, which in addition to the other requirements in the academy, includes long hours in the laboratory. In an extensive review of the reasons why women are underrepresented in many scientific careers, Ceci, Williams, and Barnett (2009, p. 218) concluded that “women’s preferences, potentially representing both free and constrained choices, constitute the most powerful explanatory factor.” They believe that it is women’s choices to be mothers and other caregivers that is the single most important reason for sex-differentiated occupational choices in many fields of science.

Because women do most of the caregiver tasks in society, it is not surprising that many women might prefer shorter working hours. In a recent study of highly successful women who also have considerable caregiving demands (children and/or aging, ill, or disabled family members) my colleague Fanny Cheung and I (Halpern & Cheung, 2008) found that these women worked very long hours, often working into the night after family members have gone to sleep, and losing what amounted to one full night’s sleep a week as compared to other professionals without these demands. As women and men prepare for future careers, they consider work in the context of their lives, so at least one possible explanation for the underrepresentation of women in STEM fields is that their low participation rates are not reflective of cognitive sex differences, instead they reflect different levels of commitment to careers that require very long hours at work.

Discrimination Against Women in STEM Disciplines

Summers’ third point about discrimination was recently addressed by Ceci and Williams (2011). They reviewed evidence of discrimination in STEM



disciplines and concluded that “recent and robust empiricism, however, fails to support assertions of discrimination in these domains” (p. 1). These results seem to be at odds with data from the IAT which show that most people associate science with being male and humanities with being female. It may be that overt measures of discrimination are less likely to show this behavior than more covert measures (Swim & Cohen, 1997). Ceci and Williams review several studies that found evidence of discrimination against women in STEM disciplines, but they counter with other studies that failed to support the idea that women in science face discrimination when applying for jobs or grants or in the space and other resources they are allotted.

Other types of evidence suggest that discrimination in higher education, including and perhaps especially STEM disciplines, is alive and well. It seems that even when women and men are on the same career trajectory, women are paid less than men. Meyers (2011) found that as the number of women in an academic discipline increases, salaries decrease. Women also get less of a pay bump when they are employed in research institutions relative to men. Thus, the wage gap persists even after controlling for differences among disciplines and types of institutions. The conclusion that there is no sex discrimination in higher education is likely to be challenged in the next several years.

PERFORMANCE AND STRATEGY VARIABLES

The idea behind appeals to performance and strategy variables is that sex differences in cognitive abilities are NOT really reflecting different levels of abilities, but instead are indicators of differences in the way males and females approach and solve problems or take tests. The idea that performance and strategy variables underlie cognitive sex differences is not a coherent theory of development like psychoanalytic theory or social ecology theory; rather it is an explanation that would apply only to cognitive sex differences. Why males and females would develop and use different strategies for solving problems or taking tests is not clear. Nor is this perspective a single coherent point of view; it is a loose categorization of reasons that have been offered to explain why the sexes perform differently on cognitive tasks. Consider these explanations.

Speed–Accuracy Tradeoffs

A difference in speed of problem solving is not a sufficient explanation of the sex difference on Mental Rotations Test.

—Susan M. Resnick (1993, p. 71)

The SATs are important in determining college admissions and because they are so critical in determining who goes to college, which college is likely to find an applicant acceptable, and what someone is likely to study, these tests

are considered in several places in this book. These tests also have excellent statistical properties (psychometrics) and are available for research purposes to many researchers. Thus, we know a good deal about performance on these tests. Both the verbal and mathematics sections are taken under timed conditions. Suppose females, on the average, respond to timed pressures in a different way from males. Suppose, further, that there are no real differences in these cognitive abilities between the sexes (or the differences are too small to be consequential), but females take a more cautious approach to selecting answers. If there is not enough time to complete the test, and females routinely take more time to select answers because of a bias to respond more slowly, then we would have a situation in which females score significantly lower than males.

This hypothetical scenario served as the basis for several studies. There are some indicators that at least part of the sex differences that are found in timed tests is due to differences in response styles. In a study of sex differences on the National Assessment of Educational Progress in Science (NAEP), the researchers found consistent sex differences for children aged 13 to 17, with males answering about 5% more questions correctly than females (Linn, De Benedictis, Delucchi, Harris, & Stage, 1987). This corresponded to a $d = 0.27$. But when they went through the types of answers picked by females and males, they found that the females were more likely to use the “I don’t know” alternative than the males were. It seems that females have less confidence in their science knowledge or ability.

In another study of sex differences in mode of responding, Goldstein, Haldane, and Mitchell (1990) found the usual male advantage on a mental rotation test, but when they analyzed their data using the ratio of correct responses to the number of items attempted, the male advantage on this test was eliminated. This means that the females did not attempt to solve as many problems as the males (perhaps the females worked more slowly and cautiously), but they answered correctly the same proportion of attempted problems as the males did. In a second test of the hypothesis that sex differences would be eliminated when time constraints were removed, these researchers found no sex differences in untimed administrations of the mental rotation test. These results provide strong support for the idea that cautiousness or some other response bias was responsible for a large portion of the sex differences found in cognitive abilities (Gallagher, 1989, 1998).

Recently, Voyer (2011) conducted a meta-analysis of the research literature on time–accuracy tradeoffs with visuospatial tests. He examined the results of 36 separate studies to determine if sex differences depended on timed conditions. He found that sex differences in mental rotation are linearly related to the time available for test completion, so they were smallest in untimed conditions and largest under strict time limits. Overall, he found that sex differences favoring males in mental rotation are large ($d = 0.70$). The magnitude of the male advantage was significantly reduced, but it remained significant without time limits. Thus, although speeded conditions increase the size of the sex

difference, it remains large even under untimed conditions. Voyer suggested that the high male performance under untimed conditions represents a ceiling effect, which is similar to a floor effect in that the two groups come up against a limit on their performance, in this case, with both groups achieving high scores, making it difficult to discern group differences.

There is a test of verbal abilities that is known as the Stroop test. In the Stroop test, the stimuli are color names (e.g., the words “green,” “blue,” “red”) which are printed in different color ink. For example, the word “red” might be printed in blue ink and the word “blue” might be printed in yellow ink. The task for the subject is to name the ink color as quickly as possible while ignoring the word that the letters form. Although this may seem like a simple task, it is surprisingly difficult to ignore the printed word and name the ink color. Nayak and Dash (1987) found that “girls are superior to boys in response speed” (p. 88) in the Stroop test. Thus, at least under some testing situations, girls respond faster than boys. If females are more cautious in responding, and therefore slower to respond, then we would expect this response bias in any timed task. The fact that girls were faster at responding to verbal stimuli suggests that a generalized tendency to respond cautiously cannot be the cause of all of the sex differences found in reaction times. Of course, by now you should be able to recognize how the conclusion that longer reaction times for females are creating a false appearance of cognitive sex differences on some tasks could be questioned. Recall that reaction time is one measure of intelligence or cognitive functioning. Psychologists who use reaction measures as an ability index are not going to accept untimed versions of the same test as a measure of intellectual prowess. If reaction time really reflects “thinking time,” then it is a measure of cognitive speed or cognitive ability.

Several researchers have objected to the idea that sex differences can be reduced by computing the ratio of the number of problems solved correctly to the number of problems attempted as being nonsensical (Masters, 1998). For example, if in a given time period, say 3 minutes, one person attempts only one mental rotation problem and gets it correct, then this person’s ratio is $1/1 = 1$. For this person, 100% of all of the attempted problems were solved correctly. By contrast, suppose another person attempted 8 mental rotation problems in the same 3-minute period and got 7 of them correct. This person’s ratio of the number of problems solved correctly to the number of problems attempted would be $7/8$, which is less than 100% correct. By the logic of ratio scoring, the first person would be judged to have better mental rotation skills than the second, which seems to make no sense because the first person got only one problem correct in 3 minutes and the second got 7 correct in 3 minutes. Other studies have also reported that males and females are about equal in their reluctance or readiness to guess when they are not sure about the correct answer, so confidence and the willingness to take a risk are probably not causing cognitive sex differences (Delgado & Prieto, 1996). In a test with four different types of visual-spatial tasks, the error rates for each of the tasks were comparable

between women and men, but the men were significantly faster (all d values between 0.63 and 0.77; Loring-Meier & Halpern, 1999). Thus, the idea that women work more slowly, but perhaps more accurately, cannot be used to account for cognitive sex differences.

Learning Styles

One suggestion is that boys have more autonomous learning styles, which means that they prefer more self-directed learning. According to this hypothesis, girls learn better when they are given directives. Therefore, males perform better than females when the test is not similar to the topics that are taught in school (as in standardized tests), and females perform better than males when they are tested on material that is similar to that taught in class (as in school exams; Kimball, 1989). Although this is an interesting possibility, there are no independent confirmations that males and females have different learning styles or that girls perform better under directed conditions. A recent review of the entire field of learning styles has landed this concept on the list of “great myths of popular psychology” (Lilienfeld, Lynn, Ruscio, & Beyerstein, 2010). Thus there is no good evidence that people learn better if instruction is matched to learning styles or that learning styles exist at all (Pashler, McDaniel, Rohrer, & Bjork, 2008). People have strong beliefs about learning styles, but these beliefs are not supported by research.

An important part of the mathematics sex differences debate is which is the better measure of mathematical abilities. Is it grades which reflect achievement on multiple tests over the course of a semester or a year or is it single-session tests like the SAT-M? The SAT-M is not closely tied to any particular instruction; course grades are. Some will argue that cognitive tests that are independent from the learning setting and the teacher are “fairer” because they are not influenced by teacher bias or by factors unrelated to ability like working neatly or behaving well and smiling in class. Others will argue that the cognitive test may include material that favors one sex or the other because they have not had the same learning opportunities to prepare for it. It seems that this question is like many of the others posed in this book. The answer is not one or the other, but both are important depending on what you want to know about mathematical abilities.

A COMPARISON OF THE THEORIES

A theory is an explanation. It is a way of understanding something; in this case the “something” is the complicated findings related to sex differences in cognitive abilities. A good theory can account for a wide range of data and can be used to make predictions that are testable. Good theories also allow experimenters to design interventions and manipulations that will bring about a

predicted change. Let's consider the ten theoretical perspectives presented in this chapter with these criteria in mind. As you probably noticed, I have not called all of the alternative explanations "theories" because not all of them are well developed. Some of the explanations were designed to explain all of personality (e.g., psychoanalytic theory) and others are narrow in the scope of variables they attempt to explain (e.g., performance and strategy variables), but what they share is a way of thinking about the "why" of cognitive sex differences where the "why" variables are mostly found in psychological effects of societal practices and values.

Each of the theoretical perspectives begins with a different notion about the nature of the forces that cause humans to conform to sex role stereotypes or to develop in ways that favor some cognitive abilities and not others. Salient points about each of these perspectives are summarized in [Table 7.1](#) where the origin, basic mechanism of action, secondary influences, and outcomes are compared.

In comparing these ten theoretical perspectives, it is difficult to determine which is "best" because there are areas of overlap among them, they each begin with a different starting point, and they attempt to solve a different part of the puzzle. It is likely that rewards and punishments, imitation of same-sex models, and gender schemas all operate in the establishment and maintenance of sex role stereotypes. It seems obvious that expectancies and values would play a role in determining cognitive development and the results of any specific test. Yet, none of these is a sufficient explanation for the pervasive patterns of cognitive sex differences. Of course, each of the theoretical perspectives might have a "small piece of the best explanation" for the way psychosocial variables operate in sex-differentiated ways that create and maintain cognitive sex differences.

CHAPTER SUMMARY

Ten different theoretical perspectives on the question of "why are there sex differences in cognitive abilities?" were presented. These perspectives differ from those presented in earlier chapters in that they are predicated on the belief that the reason for these differences lies either exclusively or primarily in the way societies define and prescribe roles for its males and females. There are major differences among these perspectives, despite the fact that each emphasizes the nurture end of the nature–nurture continuum.

The oldest theory is Freud's psychoanalytic theory, which was proposed over 100 years ago as an all-encompassing theory of development, psychotherapy, personality, and psychopathology. As applied to the questions of cognitive sex differences, it places the origin of these differences in the biological differences between females and males. A major premise is that the way individuals resolve psychosexual conflicts during the preschool years has life-long effects on personality. If these conflicts are resolved well, the developing

Table 7.1 A comparison of ten (primarily) psychosocial perspectives

Theoretical perspective	Origin	Mechanism of action	Secondary influences	Outcome
1. Psychoanalytic	In the child's understanding of visible differences between female and male genitals	Resolution of sexual urges during preschool developmental period	Rewards and punishments for appropriate sex-typed actions	Identification with same-sex parent and subsequent adoption of sex-appropriate roles and behaviors
2. Learning theory	In sex-differentiated rewards and punishments	Basic principles of reinforcement and punishment	Could include alternative ways of learning	Rewarded behaviors increase in probability and punished behaviors decrease in probability
3. Social learning theory	In the multiple ways males and females exhibit different behaviors and receive different outcomes	Observational learning—learn from observing models who are similar to oneself and knowledge of one's sex	Could include direct rewards and punishments	Children learn to match their behaviors to same-sex models
4. Social ecology	Sex, like age, influences development depending on sociohistorical context	Context variables are responsible for many of life's outcomes including development of cognitive abilities	Social expectations change as a function of sex-role changes with historical period	Males and females at different ages in different historical periods will develop different cognitive abilities
5. Cognitive theories	Cognitive sex differences begin with the cognitive principles that underlie how we think	Recognizing one's own sex and that each sex is permanent and that each sex engages in different activities	Reinforcement principles can play a secondary role after the establishment of "gender constancy"	Children adhere to sex-appropriate activities to maintain cognitive consistency
6. Expectancies-values-motives	In the probabilities people assign to their chance of success and	There is a multiplicative relationship between	Our values and estimates of success are learned	Low expectations of success will result in little or no effort and the increased

	the amount they value an outcome	probability of success and the value of an outcome	in multiple ways so rewards, imitation, and other theoretical approaches are involved	probability of failure, which in turn lowers subsequent expectations of success
7. Bent twigs	In general, males and females have different initial propensities	The environment will encourage development in areas where initial talent is evident	Initial biologically-based differences are recognized	Small initial between-sex differences are magnified via sex-differentiated environmental experiences
8. Gender equality and culture	The development of cognitive sex differences depends on the gender equality of one's culture	Sex-typed experiences in a culture encourage development of cognitive potentials, so like bent twig hypothesis small differences in math and reading are enlarged in supportive environments	Gender equal countries tend to be "richer" and thus allow more learning experiences	Females excel in reading, males excel in visuospatial tasks, with small differences in math in more gender equal cultures, which may reflect small initial differences that are magnified
9. Work-family conflict	Cognitive sex differences arise from different caregiving demands for women and men	Women select less intensive fields of work with shorter work hours (e.g., teaching) because of their added work at home as caregivers	Differential rewards and encouragement could also play a role	Results in the underrepresentation of women especially in STEM disciplines because of the conflict between family demands during child-bearing age and long hours in the laboratory
10. Performance and strategy variables	Cognitive sex differences are not differences in abilities, but in the way females and males perform cognitive tasks	Females are more concerned with accuracy and each sex uses different cognitive strategies	Different initial use of some strategies could be experiential or biological in origin	Inefficient strategies are not synonymous with less ability, but they can result in less achievement especially if achievement is measured with timed tests

child will identify with the same-sex parent and conform to the sex role expectations associated with one's own sex. It is only indirectly related to questions about cognitive sex differences. This perspective can be contrasted with that of learning theory, which is a general theory of learning that applies beyond the issues involved in understanding cognitive sex differences. The basic principles of reward and punishment determine which behaviors will be repeated, and in this way children learn sex appropriate behaviors.

Social learning theory recognizes that learning also occurs by observing the behaviors of appropriate models. Individuals do not need to receive the rewards and punishments themselves; a great deal can be learned through a combination of observation and modeling. The social ecology perspective also centers on the way society treats males and females differently, but this perspective emphasizes the importance of sociohistorical context. The cognitive abilities that we develop, along with critical changes in many other life variables, depend upon one's age and sex at different periods in history. Today's young men and women receive much more education than any previous cohort because of the technological era in which we live, a fact that supports the importance of sociohistorical period for cognitive abilities.

Cognitive theories are rooted in the thinking processes that enable us to understand those behaviors and attitudes that are associated with femaleness and maleness. One variant of this perspective was proposed by Kohlberg, who viewed the child's understanding of gender as a cognitive milestone. Another variant is that the categorization of activities as male-typical and female-typical is inherent in how people make sense out of the world. By creating female and male categories, we reduce uncertainty. This essential categorization process underlies human cognition and directs how we process information.

Motivation and the role of individual choice come into play in expectancy-values-motives theories that posit that individuals learn to expect success or failure at different tasks based on their past experiences. They also come to value different sorts of outcomes based on the perceived usefulness of the outcome to their own lives. Implicitly, each individual computes his or her own expectancies of success or failure multiplied by the value of an outcome and then decides how much effort to expend in achieving a goal. For example, if an individual expects to be successful in map reading and values that skill, she or he will work hard to learn it. In return for the hard work, success becomes more likely, further fueling the cycle of expectations and success. Similarly, low expectations of success will result in little or no effort and the increased probability of failure, which in turn lowers subsequent expectations of success.

The "bent twigs" hypothesis assumes that individuals are different with regard to their abilities. For example, if an individual has a small advantage in a certain area, let's say mathematical ability, and this individual receives encouragement or enriched mathematical experiences, the small advantage will grow larger. The small advantage in mathematical ability would also bias this hypothetical individual to seek additional opportunities in mathematics.

This hypothesis further assumes that there are some initial differences, on average, between males and females and these small advantages grow larger through differential learning opportunities and encouragement. The influence of culture also seems to operate as a multiplier in which small differences in abilities are magnified in cultures that are more gender equal and thus allow everyone to better develop their cognitive abilities. Gender equality seems to result in small differences in math achievement, but large differences favoring females in reading and large differences favoring males in visuospatial skills.

The future adult lives of boys and girls influence the courses they take and careers to which they aspire. In general, women do most of the caregiving and thus have a heavier workload overall than men do when they both work at comparable jobs outside the home. Women may choose to avoid careers with excessive time demands so that they can care for children and others. According to this theoretical perspective, the cognitive abilities that each sex develops reflect their plans for managing work and family as adults.

The final theoretical perspective discussed in this chapter is the idea that females and males differ in the strategies they use when approaching cognitive tasks. For example, several psychologists have posited that females are more cautious in how they approach novel problems, so they work more slowly than males, even when they are equally able. Another suggestion is that females use a less efficient strategy on those tasks where males excel, for example mental rotation tasks. The size of the sex difference on visuospatial tasks is reduced when the tasks are untimed, suggesting that speed of responding is part of the reason for the large sex differences. This theoretical perspective is more easily tested than the global theories like psychoanalytic theory. Some researchers object to this hypothesis on the grounds that speed is a central component of skilled performance so it makes no sense to talk about the reduction in sex differences under untimed conditions.

Using a Biopsychosocial Perspective to Understand Cognitive Sex Differences

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Like first-year medical students, we have dissected the body of knowledge that pertains to the immensely complex system we are trying to understand. But medical science could not proceed unless the students are able to comprehend the way the pieces work together and see the interrelatedness of all of the systems. Similarly, we need to put the biological theories, psychosocial theories, and research together because, in reality, they are as connected as the mind and brain. In this chapter, we step back and consider some of the implications of what we have learned about cognitive sex differences, raise some controversies that stem from our knowledge, look cross-culturally for universal findings, and find wisdom in dealing with complex and often contradictory findings.

ADVICE FOR “POP”

It is cruel to bring a child into the world with a blue or pink stamp on their forehead.

—Pop’s mother (quoted in Belkin, 2009, para. 4)

Newspapers around the world have featured stories about an adorable Swedish toddler, whom they call “Pop” to protect the child’s identity. Actually, there is a lot more than the child’s name that we do not know about Pop, including whether the child is boy or a girl. Pop’s parents are determined to keep that information about Pop a secret, except for a few trusted family members and friends who have sworn secrecy around revealing Pop’s sex. Pop’s parents believe that “gender is a social construction” and so as long as people do not know whether Pop is female or male, the child will not be treated according to sex role stereotypes. At the time of this writing, Pop is 3½ years old and the parents are expecting their second child. They have stated that they will reveal Pop’s sex when “Pop thinks it is time” (Parafianowicz, 2009).

Not everyone thinks that keeping Pop’s sex a secret is a good idea. For example, Susan Pinker, a psychologist with expertise in this area, believes that the many differences between girls and boys that are present at birth will make it difficult to respond to Pop’s individual needs if Pop’s sex is kept secret. Other experts are not sure if the secrecy surrounding the baby’s sex will result in beneficial or detrimental effects. Anna Nordenstrom, a pediatric endocrinologist in Sweden’s prestigious research institute, Karolinska Institutet, responded that we don’t know what determines sexual identity, but it’s more than sexual upbringing (Belkin, 2009). It is interesting to note that although many experts are uncertain about the effect of this “experiment” on Pop, the general public has strong opinions and the many websites that carry news about Pop have many hundred comments posted, with public sentiment running the entire range from applauding the parents for their brave fight against sexism to calls to have them incarcerated for child abuse. This is one controversy that we cannot resolve by examining the relevant data because we do not have large samples where the sex of a young child was kept secret. Although some people will rail against this well-intended practice and others will see it as laudatory, we really do not know if the effect will be positive, negative, or neutral regarding the extent to which Pop displays or endorses sex role stereotypes or adjusts well in childhood and beyond. And, we can only imagine a large-scale experiment in which the children’s sex is not revealed until near adulthood and the effect of that sort of rearing on the development of sex differences in cognitive abilities. Although this experiment is not possible, it would be the ultimate test of the relative contributions of biological and psychosocial variables on cognitive development.

CROSS-NATIONAL COMPARISONS

[There are] wide variations among groups in what is defined as appropriate behaviors for the genders.

—James A. Doyle (1993, p. 111)

As presented in the preceding chapters, biological and psychosocial hypotheses provide two frameworks for studying sex differences in cognitive abilities. But this division, like any other scheme for dissecting the multiple determinants of human development, is artificial because these two types of influences are inextricably entwined—we are all biological organisms that develop within a cultural environment. In every society, males receive more encouragement for engaging in male-typical behaviors with the reverse being true for girls. In westernized societies, boys are more likely to be given toys that develop their spatial skills beginning when they are young children, and they receive more rewards and encouragement for engaging in activities that further enhance these skills such as playing group sports and traveling on their own. They also have the male chromosome configuration, a preponderance of male hormones, and other biological indices that define them as male. At birth, they are classified by the shape of their genitals, and, on the average, are somewhat more active and physically aggressive than females. Because biological sex and psychosocial environment are usually confounded, it is impossible to ascertain the independent contribution of any of these variables, which is why I have adopted a biopsychosocial framework as a means of incorporating both types of influences.

All of the methods that have been discussed that attempt to disentangle biological and psychosocial influences, such as extrapolating from research with nonhuman mammals, examining medical anomalies, correlating twin data and contrasting it with biological sibling and adopted sibling data, and providing specific educational experiences to selected groups of participants, can only suggest an approximation of the relative importance of each of the variables under investigation. Another technique for approximating the relative contribution of biological and psychosocial variables is to look to other cultures.

The underlying rationale of cross-cultural research in this area is that all females, everywhere in the world, share a similar biology, as do all males. Although there are obvious differences among people in their skin color, hair texture and curl, shape of eyes, etc., the biology of femaleness and maleness is the same everywhere. Except for medical anomalies, members of each sex have the same chromosome configuration for determining sex, internal reproductive organs, gonads (sex glands), genitals, and sex hormone balance, although it remains possible that there are groups where environmental variables altered these biological indicators of sex. In addition, the demand for cognitive abilities is universal in that everyone must learn, use information,

make decisions, represent and communicate meaning, navigate through space, reason with quantities, create, decide, solve problems, and so on. In their seminal book, Cole and Scribner (1974) concluded: “we are unlikely to find cultural differences in basic component cognitive processes” (p. 193).

Societal and environmental milieus, however, differ from culture to culture. Consider, for example, the implications of cognitive sex differences research conducted in a society whose sex roles are very different from those of western cultures. Suppose that some hypothetical society existed in which sex role stereotypes were the reverse of those in North America, such that girls were encouraged to succeed in the mathematics and science areas and boys were encouraged to be nurturant and to engage in more “quiet” activities like reading and sewing. If we were to find the same cognitive sex differences that we typically find in westernized societies and cultures, then we would have strong support for the importance of sex-related biological variables in the determination of cognitive abilities. Conversely, if we were to find the reverse or a different pattern of cognitive sex differences, or no differences at all, then the psychosocial variables would have received a strong endorsement. Thus, one of the major advantages of cross-cultural research is that it allows the possibility of, at least partly, unraveling biological and psychosocial contributions to cognitive sex differences. Although there are also problems in interpreting cross-cultural findings because of confounding variables, including differences in the socioeconomic status of the people in the area being studied, differences in childhood rearing practices, religious beliefs about the appropriate roles of men and women, and many more.

The Work of Margaret Mead

I was brought up to believe that the only thing worth doing was to add to the sum of accurate information in the world.

—Margaret Mead, anthropologist, quoted in *The New York Times*,
August 9, 1964

Margaret Mead (1901–1978) is probably the best known anthropologist in the world and certainly the most controversial. As testimony to her widespread influence, *Time* magazine named her “Mother of the World” in 1969. One of her most influential books was *Sex and Temperament in Three Primitive Societies* (Mead, 1935), which was a study of the people of New Guinea. Mead contrasted the sex roles of three different tribes: Women and men in the Arapesh tribe shared child-rearing duties, both sexes were gentle, and showed similar behaviors. By contrast, men and women in the Mundugomor tribe also displayed similar behavior, but both sexes disliked children and child care and both were aggressive. The women and men in the Tchambuli tribe had distinct sex roles, with the men being more dependent and spending much time on grooming and women supporting the family and being the more dominant sex.

The message that Mead learned from these societies was clear: Gender is created by societies, and men and woman can assume either dominant or submissive roles, depending on societal dictates.

Mead's message was challenged soon after her death by another anthropologist, Derek Freeman. Freeman also studied various tribes in Samoa, and he concluded that Mead was either duped, dishonest, or both. Numerous books and journal articles have been written about this scientific war. The Science Discovery Channel lists the Mead–Freeman controversy as one of the top 10 science feuds of all time. Most historians conclude that Mead was, at least in part, wrong in her observation that humans are completely flexible in the extent to which they can assume various societal roles. Of course, not all men are more aggressive than all women, but across every culture except for those documented by Mead, males are, on average, more aggressive than females, and it seems unlikely that this pattern was significantly altered in just one remote society. Societies as a whole can encourage nonviolence and harmony, but there are probably biological constraints such that males would be the more aggressive members even in peace-loving societies. Of course, this experiment has never been done, but data from around the world and across time suggest the outcome for this thought experiment.

Contemporary Cross-Cultural Research

A new type of thinking is essential if mankind is to survive and move toward higher levels.

—Albert Einstein (1946)

In the last edition of this book, which was published in 2000, I wrote that “unfortunately, high quality cross-cultural research that employed comparable measures in a wide variety of cultures is rare.” I am pleased to report that over the intervening span of more than a decade, cross-cultural comparisons have become quite common and are increasingly becoming the norm in many areas of research. The use of the internet for data collection has made cross-national research much easier. The ease of data collection via the internet has been coupled with an increased awareness that we need a psychology of all people, not just people in western industrialized countries. It remains true that there is much less research conducted in countries that do not have adequate access to the internet, such as isolated groups around the globe, and in several places where the government has restricted access to the internet for its citizens.

Throughout this book, I have referred to several studies that collected data on the BBC website and thus were able to attract hundreds of thousands of participants from over 50 countries. These data are remarkable in several ways. First, the large number of participants allows researchers to investigate topics at multiple times in the life span because of the relative ease in reaching older adults and other groups such as middle-aged men that are difficult to get

into research laboratories. For example, with almost 200,000 participants, researchers were able to investigate aging effects for several cognitive tasks using participants from over 50 countries (Maylor, Reimers, Choi, Collaer, Peters, & Silverman, 2007) to conclude that at every age in the adult life span, women outperform men (on average) in category fluency and memory for object location, and men outperform women on mental rotation and judgment of line orientation. These data were described in more detail in [Chapter 3](#). This conclusion is strong not only because of the large number of people who participated, but also because internet studies are poorly controlled, which makes it less likely to find significant differences. The bias against finding sex differences with internet studies increases the confidence we can have when differences are found. Of course, the large number of participants also means that small effects would be statistically significant, but the effect sizes are all large enough to be meaningful.

The Broader View of Sex Differences Research

People use bad words for girls . . . They scream at them on the streets. When I see that, I don't want to be a girl. When I am a boy, they don't speak to me like that.

—Afghani girl who passes for a boy (quoted in Nordberg, 2010)

There are political ramifications to research into any aspect of sex differences because beliefs about the roles that men and women should and do play in any society are always embedded in a historical, religious, and political context. These various contexts provide information about cognitive sex differences that is only available when we look at many cultures. Consider, for example, the common practice in Afghanistan of having girls “masquerade” as boys because of the economic and social pressures that families with all girl children face (Nordberg, 2010). When a girl is disguised as a boy, she can get an education, work outside the home, bring in much-needed income for the family, and is free to travel unaccompanied by a male family member. No one knows how common the practice of “passing” girls as boys is in Afghanistan, but a news reporter documented numerous such cases. Usually, the child reverts to being female at puberty when she can no longer continue to pose as a boy. The ability to “be a boy” throughout childhood and then a woman in adulthood suggests considerable flexibility in how we can act out prescribed sex roles.

It should be apparent by now that the “truth” about cognitive sex differences is incredibly complicated, with large bodies of data showing both similarities and differences between females and males. As discussed in [Chapter 3](#), there are more males than females in the high ability tails of (many) math and science distributions, but the ratio of high achieving boys to high achieving girls has decreased from 13:1 in the 1980s to between 3:1 and 4:1 since the early 1990s

(Wai, Cacchio, Putallaz, & Makel, 2010). Although the proportion seems to have leveled off across the last 25 years, it could continue to decline given the rapid changes in only two decades. A cross-cultural examination of extreme giftedness in mathematics found that the proportion of women in this elite group varies depending on the extent to which girls' participation in mathematics is encouraged. In a study of winners in the International Mathematical Olympiad, Andreescu, Galian, Kane, and Mertz (2010) concluded that "some Eastern European and Asian countries frequently produce girls with profound ability in mathematical problem solving; most other countries, including the USA, do not" (p. 1258). The authors go on to state that there are many girls with profound aptitude for mathematics that are rarely identified because of sociocultural and other environmental factors. Data from the International Mathematical Olympiad show that the top performing countries in producing gifted mathematicians are largely Asian and Eastern European, with big differences in the percentage of women participating from each country. The biology of femaleness is the same in all of these countries, so simple biological explanations cannot explain the variations among countries. Of course, the data also show that women are still a minority in their participation in every country. Thus, like much of the data on cognitive sex differences, these data can be used to argue that females around the world are represented at a much lower rate than males (suggesting the importance of biological influences) and that females are increasingly present among the highest achievers in mathematics (suggesting the importance of psychosocial influences)—both are accurate statements.

The Devalued Female

When a son is born,
 Let him sleep on the bed,
 Clothe him with fine clothes,
 And give him jade to play . . .
 When a daughter is born,
 Let her sleep on the ground,
 Wrap her in common wrappings,
 And give broken tiles to play . . .

—From Book of Songs (1000–700 BC, quoted in Baculinao, 2004)

One truth that seems to hold up across cultures is the relative devaluation of what is female. In a newspaper article on helping couples select the sex of a child they are about to conceive, a physician in this field warned, "If we had 1,000 women coming to us in the next year, and all were going to have their first baby, and if all could easily select the sex, there's a substantial chance that we'd have 800 boys" (Barry May, Chief of Obstetrics and Gynecology at the Women's Hospital in Laguna Hills, quoted in the *Los Angeles Times*, September 5, 1990,

p. E2). This is a frightening thought as we quickly approach a time when sex selection techniques will be widely and easily available. You may be thinking that this is an old quote and that the preference for sons has surely declined over the past 25 years. According to sex ratio data published by the U.S. Central Intelligence Agency in *The World Factbook* (2010b), there are many countries in the world where being female is, for many, a death sentence. The usual sex ratio at birth is approximately 104 to 105 male babies born for every 100 female babies born, with the sex ratios approximately equal during the adult years of 15 to 64, followed later in life by more females than males. These values reflect the fact that males have a higher mortality rate in infancy and, on average, men die at an earlier age than women. But there are some regions of the world where male births and survival into adulthood are significantly higher. For example, the birth rates in China and India are 110 and 111 boys born for every 100 girls born—a rate that suggests selective abortion of girls. But, even these data are misleading because there are regions in China and in India where these values are as high as 120 boys for every 100 girls (Baculinao, 2004).

Stop reading for just a moment and write down your answer to this question: If you could select the number and sex of your children, how many children would you have and what is the order you would choose for boys and girls?

Every year for the last two decades I have asked students in my college classes to write down the number of children they would like to have and the order in which they ideally want to have girls and boys. I have taught in several different countries (e.g., Turkey, Russia, Canada, and Mexico) and types of universities, but despite large differences, the modal response is two children, first a boy, then a girl. If students reply that they want one child, it is most often a boy; if it is three children, they are most likely to want a boy, then a girl, then a boy. The students in my classes are not a random sample of the population: they are well educated and more likely to hold egalitarian attitudes than the general population. Yet, if they acted on their stated intentions, even they would have an excess of first-borns who are male, and an excess of males overall. In a short time, those personality characteristics associated with being either an only-child or first-born and those associated with being male would be so confounded it would be difficult to separate them.

In the United States, the preference for sons is more subtle than selective abortions, which are practiced in some other regions of the world. Here is just a sampling of the data that support this conclusion: families with two daughters are more likely to have a third child than families with two sons, unmarried pregnant women who undergo ultrasound to determine the sex of the yet unborn child are less likely to be married at the time of the child's birth when the child is a girl than when it is a boy and divorced women with a son are more likely to remarry

than divorced women with a daughter (Dahl & Moretti, 2004). The main idea is that many females and males enter the world with different value attached to their birth. Some might wonder why there are not more sex differences across all measures given the sex-differentiated lives that many children live.

CHANGING DATA, CHANGING MINDS

Please try this important experiment:

Take a few minutes and reflect on the theories and research results that were presented in the hundreds of pages in this book. Think about your beliefs when you first picked up this book and compare them to what you now believe to be true. Have your beliefs changed in any way? If so, how? What information was most influential in changing your beliefs? If you have not changed what you believe to be true about sex differences in cognitive abilities, think about the reason for the lack of change. Did you evaluate the information fairly? Did you maintain both the open mind and the amiable skepticism of a scientific thinker?

If you are like most people, then you are already thinking that you are not like most people. In other words, most people like to think that only “other people” are average, but you are unique and not like the average-others. But, like it or not, as you read the chapters in this book, you probably examined the evidence for and against each hypothesis with a bias for information that supported your own preferred views of what, where, why, and how the sexes are both similar and different with respect to cognitive abilities. This tendency is not surprising because the preference for information that supports what we believe to be true helps us maintain a consistent set of beliefs and a fairly constant world view (Halpern, 2003). The data concerning cognitive sex differences have been accumulating at a rapid rate, and there are not only new data (e.g., cross-cultural comparisons), but also new kinds of data (e.g., brain imaging techniques that show areas of brain activity while normal people engage in different types of cognitive tasks) that provide support for new conclusions about cognitive sex differences. Shouldn’t you rethink your beliefs about cognitive sex differences based on this new information?

Confirmation Bias

Once they form a hypothesis, people tend to search for information that supports it. That is, they assume the truth of the hypothesis in question, and search for evidence accordingly.

—Barbara O’Brien (2009, p. 315)

The tendency to look for and use information that confirms what we believe to be true is a powerful and pervasive effect. It operates in a wide range of settings, and few of us are even aware of the many times that our own thinking is influenced by this bias (Cox & Popken, 2008). Confirmation bias is the predilection to seek and utilize information that supports or confirms one's hypotheses or premises while ignoring or discounting disconfirming evidence. It involves building a case to justify a conclusion that has already been made. When we reason, we evaluate evidence to reach a conclusion. By contrast, when we rationalize, we begin with a conclusion and then look for evidence that will support it (Nickerson, 1998). In building your own conclusions about cognitive sex differences, did you use reason or rationalization?

The tendency to seek confirmation for those beliefs that we believe to be true is very strong. Scientists may be particularly "swayed by 'confirmation bias'—the tendency to look for and perceive evidence consistent with our hypotheses and to deny, dismiss or distort evidence that is not" (Lilienfeld, 2010, para. 2). Scientists are rewarded with grants, tenure, publications, and career success when their hypotheses are confirmed, so they are motivated, even if they are not consciously aware of the motivation, to disregard or reinterpret negative findings. But confirmation bias is not just for scientists—it can be seen everywhere. Consider a study of the effects of testosterone on human bargaining (Eisenegger, Naef, Snozzi, Heinrichs, & Fehr, 2010). The Ultimatum Game is a popular paradigm for studying bargaining. In this game, players are given 10 monetary units (for the purpose of this example, let's call it 10 euros). Player A can decide how to split the money with Player B. Player B can then accept the split or, if Player B rejects it, neither player gets any money. Most people find an approximately 50–50 split to be "fair," and will accept any split that is around 5 euros (for this example). But if Player A gives Player B much less, let's say 1 euro, Player B is likely to reject that offer and neither player gets any money. What would you expect to happen if Player A were given a high dose of testosterone before playing? Most people expect that the extra testosterone will make Player A more aggressive and less likely to offer a "fair" split. In a double-blind placebo-controlled experiment (recall that means that some players received testosterone shots and others received a placebo, which should not affect behavior, and neither the participants nor the experimenters knew who got the testosterone or the placebo), participants who believed that they received testosterone were "less fair" in the monetary split they offered the other player, regardless of whether they received the placebo or the testosterone. In other words, when participants (in this study they were all women) believed that they received testosterone, but really did not, they behaved as though the shot they received made them more aggressive. They acted in ways that were consistent with their beliefs about the effects of testosterone, even when they really did not receive testosterone. Beliefs about hormones affected how the participants acted. It is important to remember how our beliefs can affect our behavior and our interpretations of the behavior of

other people. This example shows how the bias to seek confirming evidence can be translated into behavioral change.

Consistency is the Hobgoblin of Closed Minds

Attitudes about controversial topics like cognitive sex differences are highly resistant to change because these attitudes are embedded in a system of values (e.g., suppose you believe that all people should have the same abilities), a social identity (as a female or a male), and other related beliefs (e.g., all the girls you know are good in mathematics). This web of beliefs creates a kind of barrier that makes new information that runs counter to the beliefs very difficult to assimilate (Kendrick, Neberg, & Cialdini, 1999). The unwillingness to consider new information is the hallmark of a “closed mind.” Given all of the information you now know about the topic of cognitive sex differences, have you changed your thinking about this topic in any way? If not, was it because you closed your mind to information that did not conform to your prior beliefs?

Note that these questions are an attempt to get you, the reader, to reflect on what and how you think about the controversial topics presented in this book. I have not tried to tell you how to think. Instead, I have presented the information in the fairest way that I can and have asked that you consider the strength and consistency of the evidence and theories that were presented and that you remain open to new information and ideas while also using the rules of critical thinking and scientific understanding as a guide.

What’s the Answer?

We conclude that early experience, biological factors, educational policy, and cultural context affect the number of women and men who pursue advanced study in science and math, and these effects add and interact in complex ways.

—Diane F. Halpern, Camilla P. Benbow, David C. Geary, Ruben C. Gur, Janet Shibley Hyde, and Morton Ann Gernsbacher (2007a, p. 1)

This quote is the conclusion from a “juried peer-review” article in which a group of leading scholars considered the evidence for and against sex differences in math and science. After countless hours reviewing all of the available data, these scholars (I was fortunate in being included) concluded that many different variables interact to create sex differences in many cognitive areas. For many readers, this was an unsatisfying conclusion. Some readers responded to this scholarly conclusion about cognitive sex differences with, “So, you don’t know!” Others probably wondered why we bothered doing the report because the conclusion was that many things are important. But, the fact is there are many variables that interact to influence the cognitive development in males and females, and that really is the best answer.

Any reader who picked up this book in the hope of finding easy answers is certainly frustrated by now. At one moment the data seem to favor one conclusion, yet upon reflection or the accumulation of contradictory data, each theory seems inadequate, subject to alternative explanations, or completely wrong. This state of affairs is not unique to cognitive sex differences. It seems to be the norm in all areas of psychology and in the other sciences that are trying to understand the what, when, where, why, and how of complex phenomena. In the search for understanding why the sexes differ in some abilities, we have amassed a considerable quantity of information, although we still have many questions without answers and answers for which we have not yet formulated the questions.

One thing that we clearly know is that there is no simple or single answer for the many questions about cognitive sex differences. The answers we have are as complex as the questions we are asking. This conclusion will come as a disappointment to some readers who want a simple answer that can explain how and why females and males differ on cognitive abilities. The disappointment is not surprising because even sophisticated scientists who work in this area want a simple answer. I recall meeting in a small auditorium with approximately 100 department chairs from graduate programs in psychology. Claude Steele, the distinguished psychologist from Stanford University, described his work on “stereotype threat” to this group. I hope that you can recall that this work showed that the fear that one might confirm negative stereotypes associated with one’s group (e.g., female or male) actually lowered performance on difficult exams (Carr & Steele, 2009; Steele & Aronson, 1995). This is exciting and powerful research and the audience responded enthusiastically, so enthusiastically that several were quick to proclaim that Steele’s work proved that biological factors are not important in determining performance on difficult tests. Similarly, I also attended a meeting of biological psychologists where Doreen Kimura, a respected psychologist from the University of Western Ontario in Canada, presented research that showed the cyclical nature of performance on several cognitive tests as a function of the proportion of testosterone and estrogen in one’s blood (Kimura, 1999). Her research was described in [Chapter 4](#). This is also an exciting and powerful finding about the role of hormones in cognitive performance. In this audience of biological psychologists, many were quick to conclude that biological variables are clearly the most important determinants of male and female cognitive abilities. I hope that you can see that both explanations are, in part, true and that the need to declare either nature or nurture as the “winner” is a false dichotomy.

With some reflection, it should not be surprising that there is no single correct answer to complex questions. There is a lore among college professors that freshmen enter college wanting to know the correct answer to life’s difficult questions. As freshmen turn into sophomores, juniors, and then seniors, the search for the right answer also changes. As students mature they come to understand that not only do we not know the right answer, we may not even be

asking the right questions. This state of affairs is not particular to psychology because all of the difficult questions in the other sciences, chemistry, biology, and physics, for example, are intricate and multifaceted. The ability to accept uncertainty and ambiguity is a sign of cognitive development because questions about complex phenomena do not have simple answers.

What's the Question?

The kinds of answers that we are willing to accept will depend on what we want to know, and correspondingly, the questions we ask. There are different levels of analysis for different sorts of questions. There are average differences for males and females on some types of tests, for some types of abilities, and for different portions of the abilities distribution. There are numerous differences in brain activity for males and females for some tasks, but the links between the brain activity or structure and performance are still indirect and weak. Females perform better, on average, than males for some measures, with the reverse true for other measures. Learning histories are always important (at least within educable ranges of intelligence), but learning is a biological phenomenon and a social one, and although everyone can (probably) improve on any cognitive task, some people will improve more quickly than others. There are multiple research questions whose answers depend upon the age and developmental phase of the subjects, the type of data collected, and the level of analysis (e.g., brain recordings, self-reports, test performance, beliefs about group and individual abilities, etc.).

It remains the task of future research to find creative new ways of finding and answering questions that may be as old as the human race. The number of questions posed by researchers is increasing as rapidly as new data are being collected. If the maturity of a field is measured by the number of unanswered and unasked questions, then cognitive sex differences is maturing well as an area of inquiry.

A BIOPSYCHOSOCIAL PERSPECTIVE

Biology and culture are isomorphic.

—William Barta (1999, p. 56)

The nature–nurture dichotomy has created a framework that has guided much of the research on cognitive sex differences. As noted in numerous places throughout this book, there are problems inherent in this dichotomy. A dichotomy requires an either/or answer, or, at best, a “more or less” type answer. Instead, we need to change the framework in which we are thinking. This framework was created, in part, by our data-analytic techniques. If you are familiar with the data-analytic technique known as analysis of variance,

then you already know that psychologists think of the effects on what we are measuring as being explained by “independent variables” and their interaction. Thus, it is common to think of environmental and biological influences as acting independently and their joint effect as an interaction. With a biopsychosocial perspective, we cannot partition variables into those that are environmental and those that are biological because all humans are biological organisms developing in an environment. Thus, biology and environment cannot be conceptualized as independent effects. The biopsychosocial perspective eliminates the nature–nurture dichotomy because within this framework there are no variables that are distinctly biological or environmental.

In biopsychosocial models, cause and effect are circular, and we cannot tell where biology ends and environment begins. Consider, for example, the findings that portions of the human brain that are unrelated to reproduction are sexually dimorphic. Although this may seem like biological evidence of cognitive sex differences, recall that structural and functional differences in the anatomy and physiology of the brain could both result from different environmental experiences and cause individuals to select different experiences from their environment or to alter the environment to which they are exposed. Classic studies by Greenough, Black, and Wallace (1987) showed that intellectually enriching environments caused neural growth in the brain and created new connections among neurons in the brain. Recall from [Chapter 5](#) the study in which adolescent girls were required to play the computer game Tetris for 3 months (Haier, Karama, Leyba, & Jung, 2009). The areas of the brain that underlie visuospatial skills showed increased cortical thickness as a result of this training. We can only imagine how a lifetime of differential experience can affect the brains of boys and girls. What people learn influences brain structures such as the density of dendritic connections and cell size; brain architectures, in turn, support selected skills and abilities, which may lead people to seek additional similar experiences, thus completing the circle of variables.

Similarly, the prenatal and postnatal hormones that are critical in brain and other nervous system development also respond to internal and external stimuli and the genetic messengers that direct development. Although this may seem like a clearly biological process, people respond to environmental experiences with changes in hormone levels. Individuals will then alter their environment in a variety of ways—for example, they may decide to flee from a fearful situation or to engage in an aggressive response. Environments are not experienced randomly. To some extent, we make selections from our environment and we alter our environment in ways that correspond to biological states. Any model of the multiple, sequentially interacting variables that cause and effect changes in hormone levels, brain structures and organization, the environments we select, and those that are correlated with our genetic predispositions, must recognize the way psychological, biological, and social variables operate reciprocally on each other. Nature–nurture is a false dichotomy; they are as inseparable as conjoined twins who share a common heart.

Although laws of parsimony require researchers to accept the simplest explanation of a phenomenon, there is little likelihood that we will be able to respond to the many questions regarding cognitive sex differences with a simple answer. Like most researchers, I find beauty and elegance in simple answers—a single explanation for all of the differences. However, I do not believe that cognitive abilities are simply determined, nor do I believe that a single answer like “It’s all in the hormones” or “It’s all because of mothers’ attitudes” will ever emerge as the origin of all sex differences in cognitive abilities. The most important components of any biopsychosocial model are the reciprocal and simultaneous effects that biology, psychology, and socialization have on each other.

Nature Needs Nurture

In a review paper on sex differences in the rhesus monkey, Wallen (1996) concluded that “nature needs nurture” (p. 364). His conclusions fit well with the biopsychosocial perspective assumed here. Wallen noted that male rhesus monkeys exhibited more “rough and tumble play” than females, but when the monkeys were raised without their mothers, the males were more aggressive than normally raised males and the females were more submissive than normally raised females. By comparison, when prenatal androgen was suppressed in male monkeys who were reared in their normal family groups, they did not appear different from control males on any of the sex-typed measures. Wallen concluded from these and other studies that the expression of a host of sex-typed behaviors is biologically possible, but the ones that actually emerge and the extent to which they emerge are shaped by the social environment. Development is always in a context and it is the totality of variables, both inside and outside the body, that determines what develops.

PUBLIC POLICY IMPLICATIONS

Public policy refers to actions taken by governmental agencies, usually for the public good. Social scientists have long argued that public policies should be informed by social science research. Although there are many different areas of public policy that relate cognitive sex differences, I selected three areas to discuss in this final chapter—whether single-sex schools offer advantages or disadvantages relative to coeducational schools, whether there should be affirmative action policies for males in schools where males are the minority, and whether hormone supplements should be permitted to enhance cognitive performance in healthy, normal individuals. Each of these controversial topics concerns, in part, personal values. As much as possible, I steer clear of value judgments and stick to the best available data. I hope that readers will reason along with me, consider alternative information, the strength of the evidence

and reasoning, and use other aspects for critically thinking through these controversies.

Single-Sex Schools

Girls and boys learn in subtly different ways, in part because of those differences in the developmental trajectory of the brain.

—National Association for Single Sex Public Education (2010)

It may seem like a short leap from the findings that there are some sex differences in cognitive abilities to the idea that boys and girls need different sorts of educational experiences. The idea that girls and boys learn differently is a fundamental premise of the National Association for Single Sex Public Education, an advocacy group for single-sex education. As new information about sex differences in the brain has been emerging, the idea of separating girls and boys because they are different in how they learn has become more popular. As readers already know, there are some differences in the brains of girls and boys, but you should also know that different experiences are also responsible for creating brain differences. If just 3 months of playing Tetris, a visuospatial game, can change the brains of adolescent girls, imagine the effect of sex-differentiated learning experiences.

Advocates of single-sex education point to many fine schools that are single-sex, but being single-sex is not what made them outstanding schools. If researchers want to know if being educated in a single-sex classroom affects educational outcomes, then the only difference between the single-sex classrooms studied (and other educational settings studied) would be assignment by sex. If a district decided to implement single-sex education and at the same time increased its emphasis on academics, for example, by assigning more homework or monitoring student performance more closely, or by including motivational speakers, adding mentors and tutors, requiring uniforms, maintaining closer communication with parents, or the myriad of other changes designed to enhance student performance, they could not conclude that any gains (or losses) were attributed to single-sex education.

Neuroscientist Eliot (2009) explained the problem of confounded research this way: “There are unquestionably many top-notch single-sex schools out there. The caveat, however, is that the advantage of such schools is not demonstrably related to their single-sex structure. As study after study confirms, the differences in test scores, AP course enrollment, and other objective measures of academic success between single-sex and coed schools melt away when researchers statistically adjust the data to correct for preexisting differences between these groups of students” (p. 308).

In an international assessment of sex differences in learning, the authors conclude that “No study to date has shown gender-specific processes involved in building up the networks in the brain during learning” (Programme for

International Student Assessment, 2009, p. 9). In other words, there is no evidence that girls and boys learn in different ways. Based on my review of all of the relevant literature, I have come to believe that sex-segregated education is more likely to be harmful than beneficial and that much of the data in favor of single-sex education is based on flawed research. For additional information, I urge interested readers to peruse the materials at the website of a group of scientists who support coeducational schooling (www.coedschools.org).

One argument for single-sex schools is that there is a “boy crisis,” with boys attending college at lower rates than girls and boys dropping out of high school at higher rates than girls. Recall that a large number of males enter the military instead of college upon graduation from high school, a fact that can account for some of the sex differences in college-going rate. As explained earlier, men are entering college at increasing rates, but women have been entering at even higher rates. Consider the conclusions from a policy piece written for the Education Sector, which is an independent think tank that produces original research and policy analysis. The Education Sector is “nonprofit and nonpartisan, both a dependable source of sound thinking on policy and an honest broker of evidence in key education debates.” (Mead, 2006). They used data from the 2003 and 2005 National Assessment of Educational Progress, thus they had an extremely large and unbiased sample. Mead, a senior policy analyst, wrote: “Boys are routinely characterized as ‘falling behind’ even as they improve in absolute terms. A dizzying array of so-called experts have seized on the boy crisis as a way to draw attention to their pet educational, cultural, or ideological issues.” This debate benefits neither boys nor girls while distracting attention from far more serious educational problems—such as large racial and economic achievements gaps—and practical ways to help both boys and girls succeed in school.

In fact, white, middle-class, and Asian American males are enrolling in college at high rates, with the biggest sex differences for African Americans and Latinos. But the fact that boys score higher than girls on standardized tests in math and science from the end of secondary school and through graduate school shows that it is not true that boys are failing to learn in coeducational schools—each sex is showing superior performance on different types of measures of learning.

There is also considerable evidence that girls and boys increase sex role stereotyping when they are educated separately. Recall from [Chapter 6](#) that when gender is made salient (such as when girls and boys are educated separately), children saw the roles of boys and girls as more rigid and were less likely to want to play with children whose sex was different from their own (Hilliard & Liben, 2010). Data from single-sex schools confirm this predication. In an experiment on single-sex education in California, researchers found that constant comparisons “pitted boys and girls against one another and reinforced gender stereotypes” (Datnow, Hubbard, & Woody, 2001, p. 43). The authors concluded that girls received unwanted harassing comments and were

touched when they came together in coeducational spaces. The single-sex public school experiment in California showed that sex role stereotypes were enhanced when contact between boys and girls was reduced. Recall that stereotype threat operates when the sex of the test-taker is made salient, and it is certainly salient when the sexes are segregated in school settings. Advocacy groups for coeducational schools make the case for coeducational schooling based, in part, on the idea that boys and girls need to learn how to interact in structured settings as preparation for the workplace and for family life. They maintain that it is critical that children learn to respect each other and work together harmoniously as a way of promoting respectful marriages and equitable workplaces. Given the pressing needs of our public schools, we all need to ask if the money spent on separating girls and boys could be better spent on the myriad of needs for all children in public schools.

Affirmative Action for Males

It was those very numbers that made me start to look at the breakdown of the applicant pool, in terms of the ratio of male to female, and the discovery of what was, I think, an over-emphasis on grade point average.

—Harold Reiter, Chair of Admissions at McMaster University's Medical School (quoted in Abraham & Hammer, 2010)

In 1979, women became the majority on college campuses in the United States, with the enrollment gap between women and men increasing almost every year since then. According to the U.S. National Center for Education Statistics (Peter & Horn, 2005), projections for 2013 indicate that women will make up 57% of the undergraduate enrollment. The percentage of men attending college has increased steadily over the last several decades, but the percentage increase for women has been even greater. Despite women's increased success in education, this advantage does not continue into the world of work. One year after graduation, women earn about 84% of what men earn, even when controlling for the finding that women tend to work in fields where pay is lower. Thus the question of which sex is winning the gender wars depends on which data one cites for their argument.

Affirmative action is an emotional issue regardless of which group is targeted for some advantage. It is also a term that can have multiple meanings. It could involve educational counseling about the benefits of education that is designed to keep more boys in school and inspire them to apply and succeed in higher education, and it could mean admitting males with lower academic credentials to a selective school, while denying admission to females with better academic credentials, or any combination of actions that are designed to help males succeed in school. There is a rich literature on the topic of affirmative action for women, but little on what has sometimes been called "reverse discrimination" or affirmative action for men. We can turn to the research on

affirmative action for women to see if there are parallels that might be drawn between these two objects of affirmative action.

A recent study found that attitudes toward affirmative action for women were more positive for mothers when they had daughters and no sons, but having only daughters has the opposite effect for fathers (Prokos, Baird, & Keene, 2010). There were no differences in parental attitudes toward affirmative action for women when parents had sons or a mix of sons and daughters. The authors concluded that the reason for these one-sided findings is that having daughters magnifies mothers' support for affirmative action because it aligns their own self-interest with that of their daughters. It is difficult to predict what attitudes toward affirmative action for men would be because we have no official policies for affirmative action for men. Some have suggested that pro-male policies exist, but are not openly admitted because of fear of backlash. Paul Cappon, vice-president at Laurentian University in Canada, admitted that "Schools are doing it surreptitiously, because it's politically incorrect to do it" (quoted in Abraham & Hammer, 2010). Canadian data on the percentage of men and women who apply to medical schools are shown in Figure 8.1. You

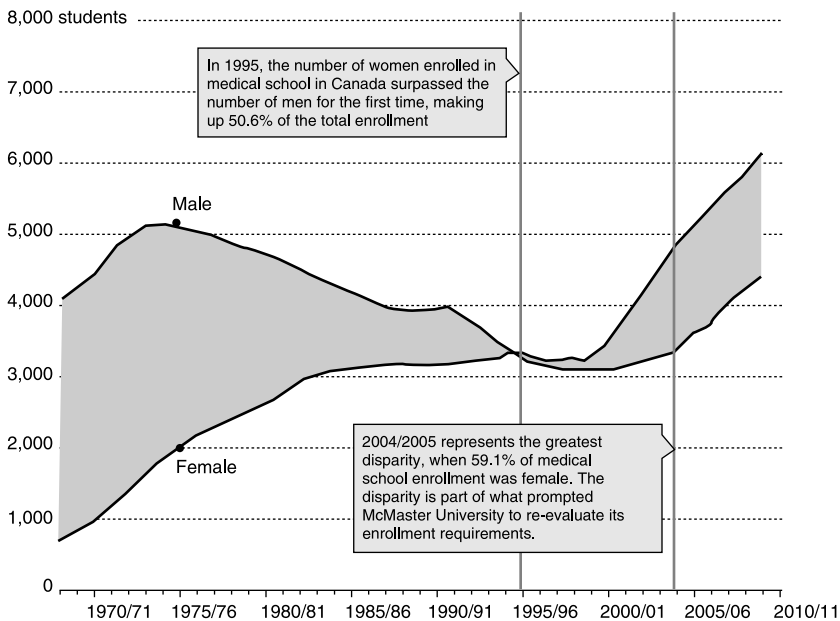


Figure 8.1 Graph shows the change in medical school enrollments from 1968 through 2010 in Canada. Is the increasing proportion of women (to 59%) a problem? If so, would affirmative action for men solve the problem? From *Globe and Mail*. Source: Office of Research and Information Services, Association of Faculties of Medicine of Canada, Dec 2009.

may recall a similar graph in [Chapter 3](#), which showed sex differences in enrollments in U.S. veterinary colleges, with a much higher percentage enrollment of women.

Affirmative action divides people because it pits two different concepts of fairness against each other. If one sex (or some other group) is not achieving at the same rate as the other sex, is that fair? Alternatively, if one sex (or some other group) is given a “bonus” on admissions for highly desirable spots in higher education, is that fair? The most recent data suggest that the gender gap in college enrollments has leveled off at 57% female (except for Latino men who are falling behind Latino women in higher education; American Council for Education, reported in Jaschik, 2010). Does the finding that sex differences in enrollments seem to be stable influence how you think about affirmative action for men? Would you come to a different conclusion about affirmative action for men if their percentage in college and professional schools were continuing to decline?

Hormone Supplements as Cognitive Aids

The appeal of pharmaceutical cognitive enhancers—to help one study longer, work more effectively or better manage everyday stresses—is understandable.

—Barbara Sahakian and Sharon Morein-Zamir (2007, p. 1157)

As a final area of public policy that is relevant to cognitive sex differences, I pose the question of whether hormone supplements should be legally available for the purpose of enhancing cognitive abilities for normal, healthy individuals. Recall from [Chapter 5](#) that at least one study found that a single injection of testosterone led to better performance by women on a three-dimensional version of the mental rotation task (Aleman, Bronk, Kessels, Koppeschaar, & van Honk, 2004). Of course, it would be irresponsible to conclude that women would perform better on visuospatial tasks if they received testosterone injections based on the scant research on this question. We also know that hormones affect numerous biological systems; most notably, there is an increase in breast cancer that is associated with estrogen replacement therapy in postmenopausal women, and testosterone is likely to cause masculinization of women and serious health risks.

The question about the use of sex hormones to enhance cognition is more of a thought experiment than an actual suggestion. What if the results with testosterone injections were replicated and concerns about other health risks were alleviated? Would it then be ethical to provide testosterone injections to women who wanted to do well on some high stakes test? What about the use of testosterone injections for women neurosurgeons before a delicate surgery or female pilots on an important military assignment where lives are at risk if their performance is not accurate? I imagine that some readers are shuddering at this

vision of a “brave new world” where cognition is altered with hormones. I also imagine that there are other readers who are thinking, “Why not?” Athletes take hormones to enhance their performance, sometimes illegally and sometimes causing long-term harm. Is cognitive enhancement similar to physical enhancement?

People take other drugs to enhance their performance. Caffeine is among the legal drugs that are used for this purpose, but there is also misuse of drugs that are prescribed to treat attention deficit disorder that are taken by people without the disorder to help them stay awake and focus. The majority of these drugs are being used in ways that were not approved by the Food and Drug Administration, a practice that is called “off-label” use. One survey found that 25% of college students on some campuses use stimulants in this way in a given year (McCabe, Knight, Teter, & Wechsler, 2004). Given these data, it is not much of a stretch to assume that if testosterone were shown to enhance cognition, then at least some people would want to take it. Of course, we know that testosterone has masculinizing effects on women and there may not be many who want to risk increased likelihood of cancer, deepening of their voice, or growth of facial hair. Nevertheless, as our knowledge about the cognitive benefits of some hormone therapies grows, it is likely that this question will emerge as part of a broader debate on the use of drugs to enhance cognition.

INTO THE FUTURE

Unfortunately, there are no crystal balls to tell us about the changing nature of cognitive sex differences. No one believes that conclusions based on today’s cognitive sex differences literature will remain unchanged even a few years from now. We must be careful not to confuse what is with what must be. But where the changes will be and when they will occur are, of course, unknown. Predictions about future research results are always risky and sometimes humorous when viewed with the benefit of hindsight; yet, I believe that we will find that the magnitude of all of the sex differences will diminish as we learn new ways to teach and learn because all cognitive abilities can improve with appropriate experiences. I also recognize that this core belief must be tempered with the new knowledge about some sex differences increasing in size as cultures become more egalitarian. Future technology may, however, create new sex differences. We know, for example, that many more males than females are pursuing careers in computer-related fields, which tend to be among the most sex-segregated fields. The nature of the skills required for success in computer-related occupations varies with different jobs. Some computer jobs, like documentation analyst or writer, require high verbal ability. Others, like programming in “low-level languages,” require mathematical ability, and still others, like computer graphic designer, require spatial ability. They all require creativity and interpersonal skills. It would seem that almost

everyone could find a niche in a computer field. Yet, computer science majors are predominantly male. If a major field of study becomes predominantly male or female, it seems likely that the skills stressed in that academic area will soon show sex differences.

Suppression of Knowledge Poses the Greatest Danger

The ideological suppression of scientific knowledge is nothing new.

—Morton Hunt (1999, p. 7)

It is not surprising that I return in the final chapter to themes that I introduced in the beginning of this book. It is critically important to a free society and to science to be able to investigate questions that may have unpopular answers. Research into the many questions about sex differences in cognitive abilities is fraught with political minefields and emotional rhetoric from every corner of the political spectrum. Throughout this book, I presented many dangerous ideas, but I have always tried to stay close to the data and honestly reflect our current state of knowledge. Flynn (1999), a New Zealand philosopher and political scientist, wrote about the many moral and ethical dilemmas associated with studies of group differences. He eloquently explained how his own beliefs about social justice were tested along with his commitment to the highest scientific ideals as he pursued questions about race differences in intelligence. It is inspiring reading for anyone who is thinking about research on a controversial topic.

But it is not just scientists and philosophers who need to struggle with conflicting values. I believe that all educated citizens have an obligation to support honest research on any scientific topic, especially ones that are controversial. Informed citizens also have obligations that extend into the way the data are being interpreted and used, the way numbers are translated into conclusions, and the way conclusions from social science research are used to determine public policies. Despite the risks of misusing research data for political purposes—social correctness or biological politics—the greatest risk is in the failure to seek answers for the most controversial questions. It is these questions that are most in need of honest inquiry. The greatest danger lies in censorship, even self-censorship, not in the open, scientific study of controversial issues.

Education for the Future

Today's young people are tomorrow's citizens, and our future is in their hands. How can we best prepare them for life in the 21st century and ensure that every individual develops her or his unique abilities to the fullest? Here are some suggestions for educators, parents, and other concerned citizens:

- 1 Separate the fact that there are average differences in some cognitive abilities between males and females from the tendency to evaluate these differences as “better” or “worse.” This is an important distinction regardless of the nature of the group. Do not permit the misuse of data for the advancement of biological politics, political correctness, or any other ideology. The truth about sex differences in cognitive abilities depends on the nature of the cognitive task, the range of ability that was tested, the age and education of the participants, and numerous other modifying and context variables. There are intellectual areas in which females excel and others in which males excel; these data do not support the notion of a smarter sex; nor do they mean that the differences are immutable.
- 2 The research summarized here is based on group averages, and no one is average. These results cannot be applied to any individual because there is a great deal of overlap in all of the distributions of abilities. For example, even though boys outnumber girls among those with reading disabilities, it is a minority of boys who are reading disabled. We should not treat all boys as though they need remedial reading instruction, nor should we treat all girls as though they are fluent readers. Many boys excel in some tests of language usage, even though there are many more verbal tasks that show an average advantage for girls. We cannot afford to write off anyone or allow group membership to limit talent development. Each individual is unique and should not be treated as though she or he is a member of some homogeneous group. Recent research has shown that beliefs about group differences exert powerful effects on thoughts and behaviors that occur without conscious awareness. These results highlight the importance of understanding stereotypes and offer a pessimistic outlook for the ease with which prejudice can be attenuated. For this reason, all of the stakeholders in education need to examine school texts for possible bias and speak to teachers and counselors about the nature of their group-based messages. We know that stereotypes become stronger when we make sex salient, so we need to be mindful of the unintended messages we are sending to our children and the other people with whom we interact. We cannot pretend that children will select options that are best suited for their individual abilities and interests, if we do not give them real choices.
- 3 Support research on human cognition. We may be close to genuine breakthroughs in cognitive aging. Research with estrogen therapy has not been as beneficial as most researchers thought it would be a decade ago. In fact, contrary to many predictions, estrogen replacement therapy actually increased cognitive difficulties in postmenopausal women, although it is likely that these negative outcomes resulted from the advanced age of the women when they began treatment. Many researchers believe that different outcomes could be expected if hormone replacement therapy had begun at younger ages, but we cannot know if this hypothesis is correct without more research. Although the research on the effects of

testosterone replacement therapy is decades behind that of estrogen replacement; both offer the possibility of hope to an aging society.

- 4 Boys mature later than girls. Be sure that flexible criteria are used when making assignments to low ability groups in the primary grades, especially in reading. Some of the boys who are slow to learn reading will catch up with their peers, if they are not allowed to fall too far behind.
- 5 We have remedial instruction for reading and mathematics, but spatial reasoning, a skill that might benefit more girls, is virtually never taught in school. There is ample evidence that training with spatial tasks will lead to improved achievement on spatial tests (Tzuriel & Egozi, 2010). Given the relationship between spatial skills and performance on mathematics tests that require spatial visualization, such training may also increase the number of males and females who are ready for careers in mathematics and science. Researchers and others need to provide all children with opportunities to develop spatial reasoning skills.
- 6 Most of the standardized tests that are used for admissions to college, graduate and professional schools, programs for gifted youth, and scholarships (slightly) under-predict female performance and (slightly) over-predict male performance (i.e., predict a higher grade point average than males actually achieve). Be sure that multiple measures of ability and achievement are used in these decisions, especially course grades and tests of writing, which tend to favor females, and standardized tests, which tend to favor males, as a way of leveling the playing fields with these different types of measures.
- 7 There are no cognitive reasons to support sex-segregated education. The fact that girls get better grades in every subject shows that they are learning at least as well as boys. For those concerned with increasing the number of females in science and math, the problem lies in convincing more females that “math counts” and to make academic and career choices that are “math-wise.” Similarly, the “boy-crisis” is better described as a poor-boy-crisis because middle-class and above boys are doing better than ever. Poor boys are no less male than their middle-class counterparts, so it cannot be their “being boys” that is responsible for their underperformance relative to girls. We need good schools for all children—schools that prepare them to live and work together.
- 8 Interpret research findings with an amiable skepticism and examine conclusions to determine if they are data-based. Conclusions about a topic as complex as cognitive sex differences will rest on the cumulative results of many studies. Although each person has social-political preferences for particular types of explanations, it is also necessary to strive to maintain an open-minded fairness when assessing a variety of theoretical and empirical findings, including the conclusions presented in this book. Explain the many pitfalls and pratfalls of this sort of research whenever you hear simple statements like “It’s all in the hormones” or “It’s all in the mother’s attitude” being made.

- 9 Be wary of brain-based explanations for the abilities or behaviors of males and females. Fine (2010) calls these sorts of explanations “brain scams,” which is the irresponsible use of findings from the brain sciences to declare that females and males are essentially different and the assumption that we can use brain morphology as an explanation for sex role stereotypes. Whenever you hear that “females are like this” and “males are like that” because of their brains, remember that there is a lot of junk science reported in the popular media and in some academic outlets. There are several areas of research where sex differences are reliably found, but none of the differences support the essentialist claims that girls and boys learn differently based on their brain type, or that one sex is better suited to become engineers, or that one sex is inherently more intelligent, to name just a few of the ideas being promoted under the guise of “science.”
- 10 Remember that the brain remains plastic throughout life, which means that it is altered in response to experiences even into very old age. Work to keep old age a time of useful activity. This is one benefit that you personally can reap when you enter your own old age.

Sex Differences, So What!

There are hundreds of observable sex differences that we, as intuitive scientists, try to explain.

—Virginia Valian (1998, p. 109)

What are the applied and practical implications of cognitive sex differences? Some “on average differences” have been found reliably across species, across cultures, across studies, and across the life span, but what does this mean for the average day-to-day lives of people? Not much. There is tremendous overlap in the abilities of men and women, so knowledge about average differences is not of great value in helping you understand any particular woman or man. It may help if you have a son who is not reading in kindergarten or the beginning of first grade to know that this is a perfectly normal rate of development, but interestingly, the same would be true if you had a daughter of the same age. Knowing that women tend to use landmarks and men tend to use cardinal directions, for example, does not mean that you would alter how you give directions depending on the sex of the person you are talking with. It might mean that you should give directions both ways so as to help both women and men understand how to get where they want to go.

Perhaps the greatest applied value lies in how we use knowledge of sex differences so that we can recognize and learn to defend against stereotype threat, to minimize grouping children by sex, and to help everyone understand how our biases can influence how we think about cognitive sex differences. Although the focus of this book has been on differences, males and females are

far more alike than they are different. Everyone benefits from quality education and a healthy lifestyle. The goal is to help every male and every female achieve their highest potential.

THE WISDOM OF NESREDDIN HOCA

In thinking about the information presented in this book, I want to leave you with a stern caveat. There are a great many ethical questions that emerge as we uncover new truths about how we think and how this knowledge radically changes our view of human nature. The possibilities for misuse of this knowledge loom large, and I spend a good deal of time worrying about the potential for misuse of the information we are uncovering.

How can we make sense of biopsychosocial explanations in which each perspective is both right and wrong? When I posed this question in a graduate course in cognitive psychology that I was teaching in Istanbul several years ago, one perceptive student recognized that I was culturally disadvantaged and suggested that I consult the centuries old wisdom of the Hoca (pronounced Ho-ja).

Nasreddin Hoca was a 13th century folk philosopher who is well known for his witty anecdotes that reflect a philosophy based on intelligence. Stories about him are well known throughout Eastern Europe, and are often attributed to other local wise men. Let me tell you one:

Hoca was once a judge. One day a man came to his house to complain about his neighbor. Hoca listened carefully and then said to him, “My good man, you are right.”

The man went away happily. In a little while the first man’s neighbor came to see Hoca. He complained about the first man. Hoca listened carefully to him too and then said, “My good man, you are right.”

Hoca’s wife had been listening to all this, and when the second man left, she turned to Hoca and said, “Hoca, you told both men they are right. That’s impossible. They can’t both be right.”

Hoca listened carefully to his wife and then said to her, “My good woman, you are right.”

The next time someone tells you that sex differences in cognitive abilities are caused by our stereotypes, or by mothers’ attitudes, or by brain structures, or by hormones, please recall the ancient wisdom of the Hoca. I ask you to recognize that each of the various perspectives on the complex issues of sex and cognition is both right and wrong. We cannot expect simple answers to complex problems. This knowledge should empower you.

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